ROADS AND STREETS

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State Aid for City Highways

In a very interesting letter, published in the December issue of ROADS AND STREETS, Mr. J. H. Howe, City Engineer of Cresco, Iowa, comments upon our editorial article, "Why States Should Build Pavements Through Towns."

Mr. Howe says: "Heroic efforts are being made to get the country roads out of the mud, while in the cities and towns we are still in the ox team days so far as any legislation calculated to speed up the construction of modern paved streets is concerned." This is true, and our editorial article emphasized one aspect of the legislative problem, namely a more equitable distribution of the cost burden. We are convinced that there will be inadequate progress until the practice of assessing street construction entirely against abutting property is discontinued.

Mr. Howe points out that the "city fathers" are usually less to blame than the state legislators for the prevalent injustice of laws relating to taxation for street improvement. He adds:

"Many members of the legislature seem to find it better and safer politics to neglect the cities and towns, but have them pay the bills. They talk farm relief but not city relief."

There is a growing irritation among city residents over the distribution of gasoline tax money, for example. They complain that in many states the residents of cities pay more than half the gasoline tax, but get only a very small percentage of the benefit derived from the tax. We predict that this complaint will grow in volume until state legislators do give adequate attention to "city relief." As a first step in that direction we urge the improving of "through streets" with money raised by gasoline and other motor vehicle tax monies.

We agree heartily with Mr. Howe that if state-aid is thus extended to cities and towns, it should not be limited to building street pavements only 18 to 20 ft. wide. A city street should not be treated like a country road. If state-aid is extended to cities and towns, state highway departments may well delegate to city engineers much of the designing and construction supervision of state-aid streets. Cooperation, in short, is needed between state and city engineering forces.

We may have been too severe in our criticism of the seeming inertia of the "city fathers" relative to changes in the practice of assessing street improvements. Where they are hampered by state laws, the inertia is not theirs alone. Yet it rests mostly upon them to initiate efforts to change the state laws. Perhaps city engineers themselves are even more responsible for the inertia than are the "city fathers."

A city engineer should be more than a technical expert on construction and maintenance of city works. His is also the province—if he will but assume it—of advocating economic reforms even in laws. No one knows better the defects of a law than the men who have to conduct their work under its prescriptions and proscriptions. The city engineer sees such defects almost daily, and he chafes under them. But the old conception of an engineer as purely a technician usually prevents city engineers from aggressively advocating changes in laws, for that is supposed to be a job for legislators.

Engineers who, like Herbert Hoover, have risen to high executive positions, have usually taken a very broad view of the province of engineering. They have regarded all phases of their economic problems as being essentially engineering, regardless of the prevalent practice.

If engineering is the application of science to problems of economic service, their engineers should not hesitate to extend their activities into the uttermost parts of the social realm. Certainly there is as much need of scientific study of the economic effects of laws and ordinances as of the scientific study of strains and stresses. Who, we ask, is better equipped for such study of political economics than is the engineer?

Automobile Taxes Near the Billion Dollar Mark

According to the American Automobile Association, car owners have paid $785,000,000 in motor vehicle taxes during 1928. This makes it certain that the taxes for 1929 will be about $1,000,000,000.

During the first half of 1928 gasoline taxes were $141,000,000, according to the American Research Foundation, and of this total more than 88 per cent went to the construction and maintenance of state and county highways. The average tax was almost exactly 3 ct. per gal.

It is safe to estimate that gasoline taxes will exceed $300,000,000 in 1929, which means that about 10,000,000,000 gal. of gasoline will be used, and that about 150,000,000,000 miles will be travelled by motor vehicles. If 8,000 drivers and passengers are killed in 1929, the death expectancy will be one death for about 20,000,000 miles of travel.

Through taxes on automobiles (licenses and personal taxes) plus the gasoline tax, perhaps two-thirds of the money spent for road construction and maintenance is now raised. A few automobile clubs continue to fight for lower taxes; but since good roads must be built and widened, and better maintenance must be provided, it seems to us that the automobile club officials that oppose gasoline and other direct taxes on automobile owners are really harming the members of their clubs. We can understand why some of the paid officials of such clubs like to "point with pride" to the legislative bills that they have defeated, but it is evident that the great majority of owners of motor cars are not so foolish as to think that they can have good roads without paying for them.

When Scientific Authorities Are Not Authoritative

The history of science abounds in instances of errors made by the highest authorities. Most of these errors have consisted in rejecting new theories that have subsequently been proved to be true. Newton for example, rejected Huygen's wave theory of light. Humbolt rejected Agassiz's theory of ice ages. Agassiz rejected Darwin's theory of evolution. Prout's theory that other atoms are built of hydrogen atoms was almost universally rejected by chemists. Tycho Brahe, the leading astromomer of his day, rejected the Copernican heliocentric theory of the solar system. Einstein's relativity theory found almost no believers for ten years.

In general it may be said that the attitude of scientists is one of extreme skepticism as to any new theory, and particularly where the new theory seems to render some old theory obsolete. Skepticism is undoubtedly desirable, for it insures the most rigid examination of new theories, but it often is carried to extremes that are really illogical. For example, although Newton had to concede that the wave theory of light explained most phenomena as well as his own emission theory, he would not accept it because it apparently failed to explain why light waves do not go around obstacles. He pointed out that sound waves bend around obstacles, and argued that if light were a wave in the ether it would bend around an obstacle. One objection to Huygen's wave theory served in Newton's mind, to offset all its merits. And this sort of reasoning, by the way, is typical of the attitude of most scientists toward any new theory. Let the new theory be ever so good in a dozen ways, but let there be one way in which it is weak, and forthwith it is judged solely by its weakness. Yet its judges themselves would have to admit that if they themselves had produced a new theory it also was weak somewhere when first produced. Charitableness toward a new theory, however, is seldom found except in its originator. To him it is a child that will outgrow its weaknesses. To others it is a mature monstrosity incapable of further growth.

Tycho Brahe urged against Copernicus that if the sun, instead of the earth, were the center about which the planets revolved, Venus should have phases like our moon and that the stars should show parallax. Copernicus replied that if man's eyesight were better the phases of Venus would be visible; and a few years later Galileo, by inventing a telescope, proved that Copernicus was right on that score. But it was not till 1840 that Prof. Bessel measured the parallax of a star, beyond dispute, and then it was disclosed that it was 670,000 times as far from the earth as is the sun. Small wonder that a distance 335,000 times the diameter of the earth's orbit made the parallax of one of the nearest stars almost inappreciable. But Tycho Brahe had never dreamed in terms of such distances, familiar though he thought he was with the heavens.

Even modest scientists—and all are not modest—often become imbued with the idea that what they know is probably immutable. They will grant without hesitation that what they know is but a small fragment of the knowable, but they are inclined to regard that particular fragment as being true beyond question. So when anyone questions its truth, they resent the question and often ridicule the questioner. Pride and egotism will crop out even in the greatest of scientists.

Read the history of science and you will read of fights between individuals and even of battles between the scientists of different nations. The theories of Descartes were decried by the English. Leibwitz and his German followers were pounced upon by both French and English.

However deporable may be a pugnacious attitude, it is infinitely preferable to an attitude of indifference. For example, English scientists remained indifferent for generations to the development of the calculus by the French and Germans, as Sir John Herschel regretfully admitted in one of his admirable addresses, nearly a century ago. Newton had founded the calculus, but his compatriots had neglected to develop it, and they long remained indifferent to its development in other countries, although the remarkable results of the application of this engine of research were repeatedly pressed upon the attention of the whole world of science.

Nothing else than a certain smug complacency among many scientists accounts for such indifference to progress. Let us not think that such complacency is entirely a matter of ancient history. Only two years ago Millikan, the famous physicist of the California Institute of Technology, spoke of "the stupendous blunder" that 19th century physicists had made in supposing that any new qualitative physical phenomenon remained to be discovered. The first big jolt that the physics of about a generation ago received was the discovery of X-rays by Roentgen in 1895. Then came the discovery of a new "atom" far smaller than the smallest atom, the electron, and the universal constituent of all chemical atoms. Then radio activity was discovered, leading to radical changes in the conception of the nature of matter. Perhaps most startling of all was the discovery that matter and energy are mathematically convertible terms, and that energy gravitates. But even more profound in its revolutionary effect, although kin to the last named discovery, was the discovery of the relativity of time and space or dimension.

Jolt after jolt has the physics of the last generation received, and the end is apparently not yet in sight. Possibly it never will be in sight. Hardly has the electron been established as the ultimate unit than it has been broken up in the research laboratory of the American Telephone and Telegraph Co. by Davisson. Has he smashed the electron into etherites or particles of ether?

With all this vast progress in 33 years, still there are many, many scientists who either scoff at new theories or ignore them. Let certain astronomers be told that the evidence points strongly toward sunspots as the main causes of weather and climatic changes, and they tell us that they are "frankly skeptical." But "frankly skeptical" usually means that they are indifferent to the evidence, and perhaps secretly hopeful that the new theory is wrong.

Authorities are usually authoritative on what they themselves have discovered and on what has long been established as true, but most of them are questionably authoritative on whatever is radically new.

W. P. Gillette

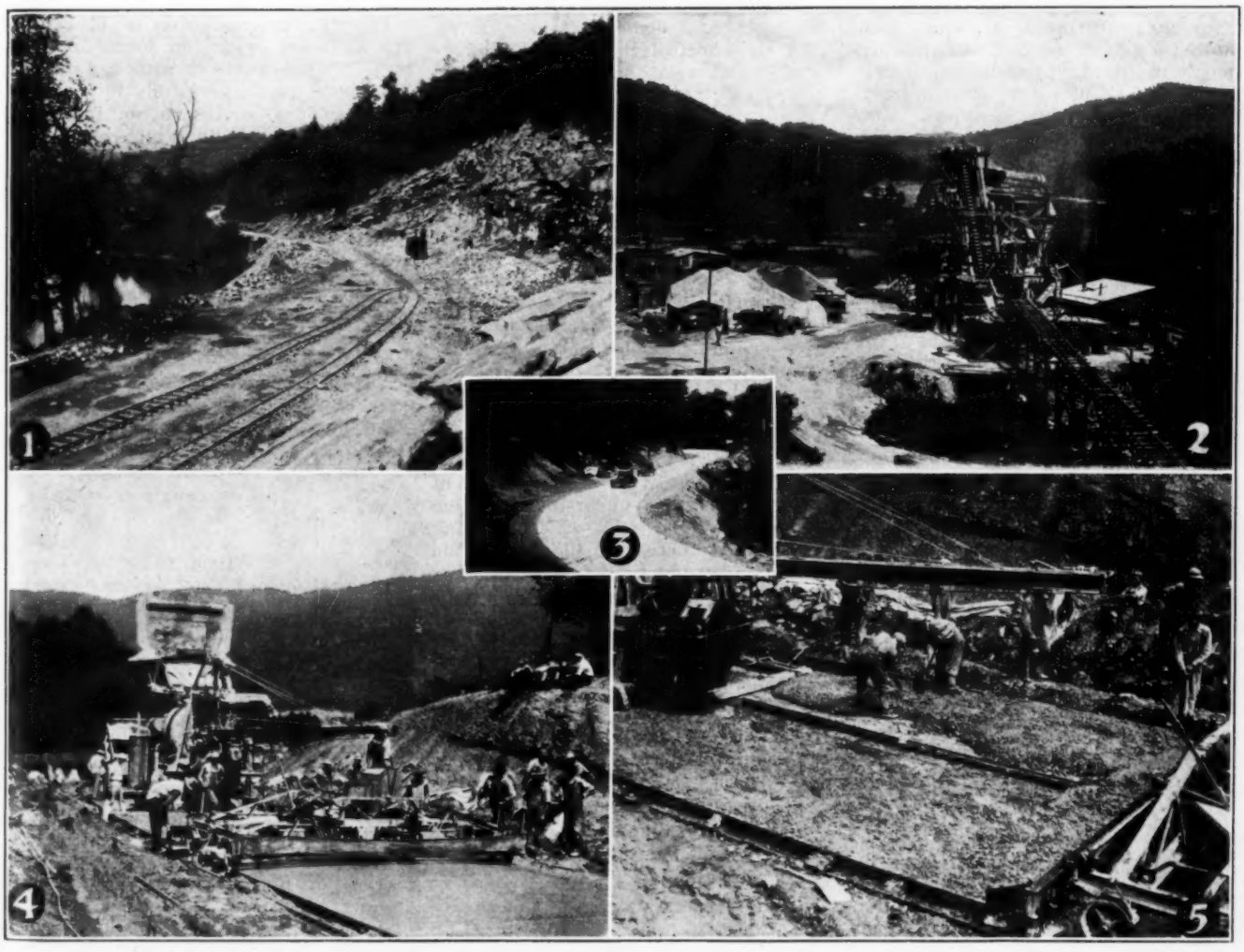
Local Sandstone Aggregates Used in Paving Highway in Kentucky

Experimental Project Results in Approval for Work Where Available

THE aggregate problem for concrete pavements in the State of Kentucky has been materially simplified as a result of an experimental job recently completed in that state. On the construction of sections A, B, and C of Project 151, a new state highway running from Harlan to Pineville, in Harlan and Bell counties, totaling 26.41 miles in length, the contractor was permitted to install a quarry, and crushing and screening plant at a point about midway between the two terminal points of the work for the purpose of producing a local sandstone aggregate for use in the concrete. In the nature of an experiment, supervised by Prof. D. V. Terrell, professor of civil engineering, University of Kentucky, and director of research of the State Highway Commission, this venture is said to have proven the merit of this sandstone for aggregate purposes. As a result, the highway department, it is said, will approve the use of such aggregate on all projects where a sufficient supply is found to be locally available.

The Project.—This road is situated in the Cumberland mountains in eastern Kentucky, and follows the Cumberland river through the two counties named. Besides being about the only route available for people wishing to travel southward from Harlan, it makes a scenic drive that should prove very attractive to tourists. This route is part of the Mayo trail, which starts at Ashland, Ky., and passes through Louisa, Paintsville, Prestonburg, Pikeville, Whitesburg, Lynch, Harlan, and Pineville. At this point it connects with the eastern branch of the Dixie Highway. Sections A and B, in Harlan County, have a total length of 15 miles, while the remaining section in Bell County has a length of about 11½ miles. The pavement is a 9-6-9 in. Kentucky section, 16 ft. in width.

Crushing Plant.—Before the start of the work the State selected and ap-



Local Sandstone Aggregates Used on This Kentucky Job.—1—The Sandstone Quarry Operated by the Contractor.—2—The Crushing, Washing, and Screening Plant at the Quarry.—3—View of the Work Between the Paver and the Finisher, Showing the Consistency of the Mix, About a 2 in. Slump.—4—General View of the Paving Operation, Showing the Equipment Used.—5—View of the Completed Road that Was Paved with Concrete in Which a Local Sandstone Aggregate Was Used.

proved seven convenient deposits of the local sandstone for aggregate purposes, and one of these sites was selected by the contractor, where he then installed quarry and crushing and screening equipment. The contractor operated this plant at his own expense throughout the work. This plant had a capacity of 289 cars, 640 tons, a day, of which about 35 per cent was sand and 65 per cent stone. The sandstone was first shot down and taken from the face with a power shovel, and transported to the crushers. Primary crushing was done in two No. 6 2½ in. Good Roads Machinery Company jaw crushers and in an auxiliary No. 4½ jaw crusher that prepared aggregates ranging in size from 1 in. to 1¼ in. Sand was crushed in a set of Allis-Chalmers rolls. A wash box with a capacity of 250 gal. of water per minute was used to clean the aggregates, and screens were provided for obtaining the required grading of both fine and course aggregate. The power required for the operation of this plant was obtained by the installation of two Fairbanks-Morse 60 H.P. diesel engines.

Nature of Aggregates.—Tests on the aggregates produced at this plant showed a 4.5 per cent of wear, absorption from 3 to 3.5 per cent, and loss by washing of 1.4 per cent. The following tabulation represents a typical sieve analysis of the sand produced at this source:—

Sieve	Per cent Passing	Per cent Retained
¼ in.	85.8	14.2
No. 20	58.8	41.2
No. 50	15.2	84.8
No. 100	2.2	97.8
Fineness Modulas	Approx. 2.4	

Coming from the washer, the sand ordinarily contained about 16 to 18 per cent of moisture, and there is therefore but little bulking until the material has had time to dry out.

The Paving Work.—The contractor, on this work, used a 21-E Koehring paver and a Lakewood finishing machine. Steel roadforms were utilized, and a subgrade template was used between the paver and the finisher. The surface left by the finishing machine was further worked with a longitudinal float. In designing the mix, a water content of six gallons to the sack of cement was specified, and the first mix tried was a 1:1.8:3.5 mix, but this was found to be a little harsh and the mix finally adopted for use with this sandstone aggregate was 1:2:3.36. This mix gave a slump of about two inches. Test samples taken during the paving were said to have shown compressive strengths of consistently around 3,000 lb. per sq. in. at 28 days.

Those Responsible.—This work was done by the Foulkes Contracting Company, Terre Haute, Ind., while the work was supervised by M. J. Warren, resident engineer, and W. S. Embry, inspector, under the direction of G. L. Logan, district engineer.

Cement Bound Roads in Great Britain

A number of municipal bodies in various parts of Great Britain are now engaged in conducting experiments in improving their secondary and rural roads with natural roadstone, such as granite, limestone basalt and whinstone, laid in cement grout. This type of construction is described in the Surveyor of July 20, by Anthony Walker, Surveyor to the Kirkcaldy District Committee of the Fife County Council. We quote from this article as follows:

The object is to coat each individual stone not only on the surface as in tar-spraying, but through the slab with cement mortar, and to bind them together with the aid of a roller. The mortar provides the strength which is wanting in a waterbound road to meet the disintegrating effect caused by internal attrition. It may be mentioned here that as a result of experiments it has been found that the breaking up of an ordinary waterbound road is due 85 per cent to internal attrition.

Non-Slippery Surface.—Apart from the problem of disintegration by attrition, the effect of the surface of a cement-bound road on mechanical and horsedrawn traffic should also be considered. When first open to traffic the surface of such a road is inclined to be dusty, but once the surface has been cleaned and the hard stone is taking the wear, a good non-slippery surface is provided.

At Ashbourne, Derbyshire, a granite surface was laid in cement grout on Buxton Hill, which has a steep gradient of 1 in 7. The surface provided gives ample evidence of its non-slippery nature. Another length which has proved successful was laid in 1925 on Stanmore Hill, between London and Watford, on a gradient of 1 in 12, and despite the fact that it carries London omnibus traffic, it is still in excellent condition. I also understand that on the new arterial road which is being constructed between Blackpool and Thornton, a distance of approximately 4 miles, an experimental section on a gradient of 1 in 18 is being laid by the corporation with a granite surface in cement grout.

An Experiment in Kirkcaldy District.—The following particulars of an experiment which I am conducting in the Kirkcaldy district may be of interest. The road where this is taking place is 22 ft. wide, and in addition to the usual horse-drawn and omnibus traffic, carries a heavy colliery traffic. The sequence of operations is as follows:

(1) If necessary, the road is scarified to a depth of 3 in., loose metal removed, then the road is formed and rolled to a camber of approximately 1 in 32. Rolling should be continued until the surface is as firm and hard as possible, so as to avoid waste of grout, and if the surface is dusty it should be well brushed.

(2) A 2½-in. layer of broken whinstone, graded 1½ in. to 2½ in., is spread over the surface and the roller (preferably eight tons in weight and of the tandem type) is run over not more than two times, to key the macadam together. A very slight watering is applied to remove dust or fine particles.

(3) A moderately stiff mortar made up of two parts clean hill sand to one part rapid hardening cement is then spread over the stone to an average depth of about 1½ in.

(4) A further 2½-in. layer of stone (graded 1½ in. to 2½ in.) is spread on the top of the mortar and the whole mass is thoroughly rolled until the mortar is brought up to the surface. The slurry is then well brushed into the interstices between the stones, and any surplus slurry is brushed forward on to new work, thus leaving the individual stones exposed to form a good non-skid surface. This results in a perfectly bound concrete mass 4 in. deep, giving a mosaic appearance to the surface and providing a very good foothold for horse traffic.

(5) It is not customary in this country to insert expansion joints in this type of construction, although these have been used successfully in Ireland. If expansions joints are not inserted, occasional cracks will, in all probability, appear in course of time, but owing to the large aggregate used, these do not ravel and become unsightly, nor do they in any way affect the efficiency of the road surface. The surface is laid continuously, and any loose stones left over on the previous day's work are trimmed off, and the new day commences with a vertical and fairly regular lateral joint.

(6) The quantities required for an area of 200 sq. yd. are approximately:

26 long tons cubical stone, graded 1½ in. to 2½ in.

5 cu. yd. clean sand.

5824 lb. rapid hardening cement.

The roller should not be run over any section for a longer period than two hours, the time to be reckoned from the moment when the mix is made up. This period must be carefully observed, otherwise the concrete will be disturbed after the initial set has taken place, with the result that it will never set satisfactorily, and the surface will start to disintegrate as soon as traffic is turned on to it. The sides of the roadway must either be "haunched" with concrete or temporary timbers should be firmly secured to prevent a lateral movement of the concrete mass during rolling.

Cost of Road.—The cost of such a road as described varies from 72 ct. to $1.08, depending on the thickness, and the cost of aggregate and sand in the district in which it is laid. These prices are, of course, for surfacing alone, and do not include the laying of a foundation.

Practical Application of the Shear Test to Bituminous Mixtures

Providing Definite Link Between Design and Actual Field Performance

By HUGH W. SKIDMORE

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THE inspiration of invention is the need of the thing to be devised. About ten years ago, asphalt paving technologists began to seriously think about the mechanics of asphalt paving mixtures. Early studies were pretty much "hit or miss" and without direction. Early in these investigations it was recognized that nothing was known of the ability of paving mixtures to withstand the effect of traffic forces, other than the bare fact that some had withstood these forces while a few had failed under certain conditions. It was obvious that the mixture was in shear when it distorted in the form of transverse waves or longitudinal ruts. Several investigators voluntarily set about the study of mixture performance and as a means of study, several tests were devised. In the main these tests sought to measure shear; some through the medium of impact; some through compression; some by extrusion and our own directly measuring simple shear of molded or cored cylinders of mixture.

The Testing Machine.—The present perfected machine was evolved from crude experimental apparatus, solving the various problems as we went along through a period of several years, but always dealing only with shear free of any complicating stresses.

The first experiments dealt with small cylinders of sheet asphalt one centimeter in diameter, and while these small specimens did not give correct values as compared with actual pavement thickness, they taught us the fundamentals of the test so that enlargement to accommodate cylinders from 1 to 4 in. in diameter was comparatively simple.

Front View of Shear Machine Set-up for 2 In. Cylinders

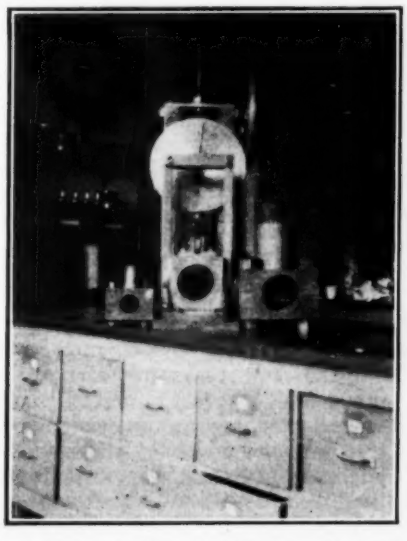
The present machine is designed to test cylinders of 1, 2, 3 and 4 in. diameter, and could be readily adapted to even larger sizes if necessary. For sheet asphalt and small stone modifications thereof we employ cylinders of 2 in. diameter and 1.5 in. depth. For all modifications of asphaltic concrete we use cylinders of 4 in. diameter and 2.5 to 3 in. depth. The exact depth of cylinder is not important so far as the shear test itself is concerned, but naturally does enter into the degree of compression in forming the cylinders under any specific load. Restricted bearing area on both the fixed and moving blocks of the shearing mechanism eliminates any variation that might be due to possible beam stresses in test cylinders of unequal length. Actual bearing area is increased proportionately as the diameter of the test cylinder increases.

The question of best procedure in molding the test cylinders was thoroughly studied over a period of about two years, and the present method, now in use for about three years, has proven itself the most reliable one with respect to uniformity of test results and likewise has great simplicity of operation to recommend it.

Preparation of Mixtures.—Mixtures are prepared in the usual way, employing temperatures consistent with good plant practice according to the materials used and character of mixture tested; usually 350° F. for most mixtures. The split-steel molds are designed against very great lateral forces so that no spread will occur in molding even at high unit loads. The molds are kept in an oven at 350° F. (or any desirable mixing temperature) until ready for use and are replaced immediately following their use. Molding can be done upon any type of press; in our own laboratory we employ a 30-ton hydraulic press. Pressure of 5,000 lb. per square inch is applied and released immediately and the compressed cylinder removed from the mold at once. Prepared cylinders are allowed to stand in an upright position over night to insure thorough cooling. Specific gravity is determined before testing for shear, which is done at 140° F. unless some other temperature is designated. Two in. cylinders remain in water-bath at least one hour before testing, and 4 in. cylinders at least two hours. The shear machine stands in the bath so that the testing is all done in the bath.

The molding pressure can be varied at will, but extensive investigation has demonstrated that 5,000 lb. per square inch agrees closely with the average good compression in the field, comparison of specific gravity of identical mixtures being used. Consequently this has become standard with us for routine testing. The immediate release of molding pressure was found to eliminate wide variations in stability results of a given mixture. No slumping of cylinders removed immediately from the molds has been found except in the rare instance of very soft, unstable mixtures which possess no shear resistance at 140° F.

Three to five cylinders are tested for a given mixture usually 5 for 2 in. and 4 for 4 in. cylinders as this provides readily workable quantities for mixing. The shearing load is applied at the rate of 2 lb. per sq. in. per second for the 2 in. cylinders and is doubled for the 4 in. cylinders, which produces comparable values for the two sizes for a given mixture.



Front View of Shear Machine Set-up for 4 In. Cylinder; Also 2 In. and 4 In. Split Steel Molds

Test Results Within 5 per Cent Variation.—The whole procedure, including preparation of cylinders, readily lends itself to accurate control and is capable of producing test results within a 5 per cent variation. If all the cylinders of a group are molded simultaneously, or the prepared mixture divided into the required units for the group and kept hot without further mixing, exceptionally close results will obtain. When the mixture for 5 cylinders is not divided but kept hot and mixing continued during the 10 minutes required to mold 5 cylinders, test results will almost invariably produce the lowest value for the first cylinder molded and the highest for the last one. Thus the ability of the test to reflect even very delicate changes in mixture and materials is disclosed, since the asphalt cement undoubtedly hardens some during the 10 minute period, especially when some further mixing takes place. This feature of variations in mixture and materials as disclosed by the test has been investigated in many directions, such as the aggregates, filler, character and consistency of the cement, mixing time for both wet and dry mix, etc., and without exception variations or changes are immediately reflected in the test results; so that it offers an invaluable medium of investigation and control.

Practical Value of Test.—Any test that provides a definite link between design and actual field performance and sets up an accurate measure of that performance in advance of actual construction has an immense practical value. The shear test as we have developed it, possesses this quality to such a marked degree that we find it indispensable in our practice in research, investigation of materials and mixtures, selection of materials and control work. Since no single factor establishes a criterion of mixture composition, it would be ridiculous to claim that this or any single test is capable of the sole determination of fitness. But it does establish a minimum stability for mixtures under any given traffic condition, and likewise sets a maximum beyond which there is no need to go. Thus is supplied a long felt need for definite means of accurately measuring resistance of bituminous paving mixtures to those forces productive of the most noticeable and serious type of failure (for which asphalt pavements have been most severely criticised by the public)—distortion under traffic.

Research and investigation during the past few years has already been productive of great practical good to the industry, and as engineers and contractors come to better understand the application of the principles laid down, these benefits become more widespread. It is probably only natural that some of the things advocated by those technologists who have thus far given the industry the benefit of their work, should have been misunderstood and that such misinterpretation should have become even more distorted through repetition by those not wholly conversant with the subject. This is often a hardship to be expected by the pioneer in thought or endeavor. But cold facts cannot long remain unrecognized and appreciation of merit usually prevails finally even though the process is sometimes slow.

Effect of Mineral Aggregate.—One of the outstanding things disclosed by these studies is the effect of the nature and character of the mineral aggregate upon stability and compressibility. The greatest single factor in stability of normal mixtures is the filler. Increase of filler means increase in resistance to displacement without decrease in workability or compressibility when the volume of bituminous cement is maintained in proper relation to mineral aggregate. Some have defeated the purpose of this law and have declared it a failure simply because they have loaded the mixture with filler and have failed to adjust the asphalt cement downward to accommodate the reduced voids in the aggregate. Whether or not you are prepared to accept the voidage principle as the basis of rational design, plain reason insists that simultaneous increase of both filler and bitumen is in defiance of the natural laws of mixture mechanics.

Rational treatment of the filler portion of the mixture is the most powerful single factor for good available to the designer. But, the subject must be understood and not misunderstood by the user. A wide variety of both fine and coarse aggregates may be used without too great refinement, likewise any and all of the asphalt cements now available and complying with standard requirements are perfectly safe and need give nobody a moment's worry, if they are not misused. A variety of filler materials are also entirely suitable for use, but no two are alike and each must be thoroughly studied and its especial merit as well as its limitations correctly determined. To my mind the subject of fillers is the least understood and the most important factor in mixture design; it provides the most fertile field for further research in both the practical and purely scientific directions.

When one comes squarely up to the revelation that one filler possesses two or three times the stabilizing value of another, or that one filler reduces voids in aggregate much faster and to a greater extent than another, he begins to realize that we have up to now known little, indeed, about the subject. And when he studies the effect of several fillers upon the mixture itself, he begins to realize that the general subject of fillers is not only important from the standpoint of our present meagre store of knowledge, but also from the practical viewpoint of mixture performance and economy of design.

Benefits from Rational Use of Filler.—We (some of us) have been accused of paying too much attention to this item, in fact some contractors have gone so far as to say we are "filler crazy." But strange as it may seem, these same persons have quickly appreciated the benefits to be derived from rational use of filler, once they learned that we were not really using 35 per cent filler just to see what would happen, in fact that we were not requiring nearly as much filler as they had been led to believe we would. Also they have been surprised to find that what was once considered high filler content does not make mitxures hard to handle and cause pavements to crack, but that it has resulted in much smoother, more stable and serviceable mixtures much less liable to cracking so long as the mixture remains in proper proportion and is not mistreated in manufacture or construction.

Bitumen Content.—Habits of thought are as easily formed as those of conduct and when bad, are sometimes as hard to break. There was a time when a really good asphalt paving man would have been greatly shocked at the suggestion of a sheet mixture containing 9 per cent bitumen being too rich to handle, yet numerous examples of such a condition have been witnessed in the last few years and we have come to realize the utter fallacy of attempting to design a mixture around an arbitrary amount of bitumen. We must accept the fact as proven that the bitumen content must be proportional to the requirements of the mineral aggregate. It is difficult to say which is the worse, too much or not enough. Surplus bitumen is more readily detected in the appearance and behavior of the mixture during construction, but is no more dangerous than a decided deficiency.

Recent researches in the art have not only proven some of the old theories unsound but have set up in their stead facts that check in theory and performance. Out of this knowledge has come practical good to the whole industry in the way of enabling the use of materials previously considered undesirable, greatly improved mixtures with respect to stability and workability, greater uniformity of composition through better understanding of what is required and how to obtain it, improved surface, greater density and durability and means of rating and rationally designing mixtures according to the actual conditions to be met in service. In view of what has already been accomplished, we look forward to even greater improvements to come.

Acknowledgment.—The above paper was presented Dec. 6, at the 7th Annual Asphalt Paving Conference.

State Highway Construction in 1928 and 1929

Expenditures Last Year and Proposed Mileage andReports from State Officials Showing Mileage and Probable Expenditures for This Year

New England States

Maine

THE work in 1928 included seven miles of reinforced concrete pavement—27 and 30 ft. wide and 9-7-9 in. thickness at an average cost of approximately $58,000 per mile; 9.5 miles reinforced concrete pavement, 20 ft. wide—9-7-9 in. thickness—average cost at $52,000 per mile; 13 miles of 18 and 20 ft. bituminous macadam pavement, 8 in. thickness, average cost $32,000 per mile; 50 miles of gravel road, 18 ft. wide—12 in. thickness—average cost of $15,000 per mile.

On the projects which were uncompleted in 1928, there remains to be done approximately four miles of reinforced concrete at a probable expenditure of $250,000. Eight miles of bituminous macadam—probable expenditure $300,000, and 12 miles of gravel—a probable expenditure of $210,000.

The program for 1929 has not yet been prepared.

The average contract price for earth excavation was $1.085; rock excavation $3.71; borrow $1.14.

Lucius D. Barrows, Augusta, Me., is Chief Engineer, State Highway Commission.

Vermont

During 1928 a total of 51.5 miles of reinforced concrete pavement were completed in this state. In addition 4 miles of bituminous macadam and 14 miles of gravel road were completed. All the above miles were flood projects resulting from the floods of late 1927. The following table gives some details of the 1928 work:

Vermont State Highway Work Completed in 1928

	Miles	Average Width Surface, Ft.	Thickness, In.	Average Cost Per Mile
Reinforced Concrete	51.5	18	7*	$45,000
Bituminous Macadam	4.0	18	3+3	39,000
Gravel	14.0	25	5–10–5	45,000
Graded and Drained	5.0	24	.....	27,000

*7 in. uniform thickness.

The incompleted work carried over to 1929 included the following:

	Miles	Width Surface, Ft.	Thickness, In.	Probable Expenditure Per Mile†
Reinforced Concrete	0.5	18	7*	$42,000
Bituminous Macadam	1.3	18	3+3	42,000
Gravel	3.1	25	5–10–5	45,000
Graded and Drained	3.0	24	.....	30,000

*7 in. uniform thickness. †Flood project.

It is not possible at this time to give any details of the program for 1929.

Hubert E. Sargent, Montpelier, Vt., is chief engineer, State Highway Board.

New Hampshire

The state highway work completed in 1928 included 30.3 miles reinforced concrete pavement, 18-20 ft. wide and 6-6-9 in. thick, the average cost for the surface being $2.14 per square yard. In addition, 1.2 miles of bituminous concrete, 18 ft. wide and 2 in. thick, were completed, the average cost for the surface only being 98 ct. per square yard. The other work completed comprised 11 miles of 18 ft. wide, 3 in. thick bituminous macadam and 6.5 miles of 21 ft. 8 to 10 in. thick gravel road. The figures are for contract work only. The reports for force account construction have not been completed.

The incompleted work carried over to 1929 comprised 6.6 miles of reinforced concrete, 2.5 miles of bituminous macadam and 2.7 miles of gravel.

It is expected that the 1929 program will be about the same as the work in 1928 and will probably include 30 miles of concrete, 10 miles bituminous and 40 miles of gravel road.

The average unit bidding prices in 1928 were as follows:

Earth excavation, per cu. yd.	$ 0.99
Class A grubbing, per acre	412.50
Borrow, per cu. yd.	1.16
Ledge excavation, per cu. yd.	3.53
Structure excavation, per cu. yd.	3.38
Field stone base, per cu. yd.	3.45
Gravel base, per cu. yd.	1.50
Crushed gravel base, per cu. yd.	2.65
Broken stone base, per ton	3.42
Gravel surface course, per sq. yd.	1.50
Bituminous macadam surface course, per ton	3.73
Apply bituminous binder, per gal.	0.07
Concrete pavement, per sq. yd.	2.27
Concrete, class B, per cu. yd.	25.63
Concrete, class C, per cu. yd.	20.36
Wood guard rail, per lin. ft.	.66
Cable guard rail, per lin. ft.	.71
Catchbasins, each	84.28
Removing trees, each	14.13
Laying 12 M. C. M. Pipe, per lin. ft.	.97
Laying 12 C. I. P., per lin. ft.	1.08
Laying 12 R. C. pipe, per lin. ft.	.89
Laying 18 C. M. pipe, per lin. ft.	1.31
Laying 18 C. I. pipe, per lin. ft.	1.22
Laying 18 R. C. pipe, per lin. ft.	1.44
Laying 24 C. M. pipe, per lin. ft.	1.63
Laying 24 C. I. pipe, per lin. ft.	1.81
Laying 24 R. C. pipe, per lin. ft.	2.04

F. E. Everett, Concord, N. H., is state highway commissioner.

Massachusetts

Up to Dec. 6, 1928, a total of 263 miles of state highway had been completed for the Sate Department of Public Works. The costs of the 1928 work are shown in the accompanying table:

Massachusetts State Highways Completed in 1928

	Miles	Average Width Surfaced, Ft.	Thickness, In.	Average Cost Per Mile
Reinforced Concrete	12.23	20 to 30	8	$65,000
Bituminous Concrete	31.89	24	4½	28,000
Bituminous Macadam	149.32	24	4 to 7	43,000
Gravel	62.48	24	6	16,000
Grading	1.66	....	....	40,000
Waterbound	3.54	18	6	45,000
Dual*	2.09	....	....	84,000

*Consists of two 10 ft. concrete strips and one 10 ft. bituminous macadam strip; 8 in. thick.

The incompleted work carried over to 1929 and the probable expenditures are as follows:

	Miles	Probable Expenditure
Reinforced Concrete	1.2	$ 237,000
Bituminous Concrete	0.2	15,000
Bituminous Macadam	32.0	2,047,600
Graded and Drained	5.6	213,000
Steel bridge	.....	91,000

The programs for 1929 will be about the same as in 1928.

Arthur W. Dean, Boston, Mass., is chief highway engineer, State Department of Public Works.

Rhode Island

The state highway work completed in 1928 and the average cost per mile were as follows:

Rhode Island State Highway Work Completed in 1928

	Miles	Average Width Surfaced, Ft.	Thickness, In.	Average Cost Per Mile
Plain Concrete	.....	.....	..	.....
Reinforced Concrete	13.26	20–40	8	$50,000
Sheet Asphalt	2.93	36	*	100,000
Bituminous Macadam	30.00	20	8	36,000

*2 in. top on 6 in. concrete base.

In addition to the above, the incompleted state highway work carried over to 1928 comprised 3.22 miles of reinforced concrete involving a probable expenditure of $200,000 and 12.48 miles of bituminous macadam involving a probable expenditure of $400,000.

The new state highway work proposed for 1929 includes the following:

	Miles	Probable Expenditure
Reinforced Concrete	3.50	$275,000
Sheet Asphalt	8.00	800,000
Bituminous Macadam	7.50	200,000

George H. Henderson, Providence, R. I., is chief engineer, State Board of Public Roads.

Connecticut

The total mileage of state work completed in 1928 was 310. The total expenditures for the last fiscal year were $16,000,000. The program for 1929 has not yet been completed.

John A. MacDonald, Hartford, Conn., is State Highway Commissioner.

Middle Atlantic States

New York

Approximately 650 miles of state highway were completed in 1928 at a cost of about $35,000,000. Approximately 700 miles of incompleted work was carried over to 1929. This will involve an expenditure of $40,000,000.

The program proposed for 1929 calls for about 700 miles of highway involving an expenditure of $45,000,000.

Paul Schultze, Albany, N. Y., is construction deputy, State Department of Highways.

New Jersey

State highway construction in 1928 totaled 153 miles. The total expenditures for roads and bridges was $27,000,000.

The program for 1929 calls for the construction of 250 miles of highway and a total expenditure of $35,000,000.

W. G. Sloan, Trenton, N. J., is state highway engineer.

Pennsylvania

The state highway completed in 1928 in Pennsylvania was as follows:

	Miles	Average Width Surfaced, Ft.
Brick	8.15	18
Reinforced Concrete	456.88	18
Sheet Asphalt	9.14	18
Bituminous Concrete	6.72	18
Bituminous Macadam	228.83	18
Gravel	2.75	18
Graded and Drained	36.40	28

The incompleted state highway work carried over to 1929 is shown in the accompanying tabulation:

	Miles
Brick	14.13
Reinforced Concrete	286.24
Sheet Asphalt	0.12
Bituminous Concrete	1.10
Bituminous Macadam	103.66
Gravel	1.35
Graded and Drained	35.75

The program for 1929 has not been decided upon, as it depends upon the action the legislature takes in regard to furnishing additional revenue.

Samuel Eckels, Harrisburg, Pa., is chief engineer, State Highway Department.

East North Central States

Ohio

The accompanying tabulation shows the mileage and cost of state highway work completed in 1928.

Ohio State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost Per Mile
Brick	66	1.8	10	$50,000
Plain concrete	206.5	1.8	7¼	35,000
Sheet asphalt	4.4	1.8	9	37,000
Bituminous macadam	90	1.8	11	23,800
Gravel	35.6	1.8		3,000
Reconstruction	37.6	1.8		
Graded and drained	73.6	1.8		16,500
Surface treated macadam	34.8	1.8		22,900
Kentucky rock asp.	2	1.8	8½	21,000

The incompleted state highway work carried over to 1929 is as follows:

	Miles	Probable Expenditure
Brick	53	$3,688,092
Plain concrete	186	4,370,338
Reinforced concrete	12	861,988
Bituminous macadam	52	1,622,451
Graded and drained	87	1,626,343
Waterbound macadam	13	198,909

The program for 1929 has not been decided upon.

H. J. Kirk, Columbus, O., is director of highways.

Illinois

The division of highways of the department of public works and buildings completed from Jan. 1 to Dec. 6, 1928, 1,255 miles of concrete road, 29 miles of brick and 9 miles of gravel road. Of this mileage, 214 miles of concrete and 9 miles of gravel were built and paid for by the counties but were built under state supervision and will be maintained by the state upon completion. In addition to this there were 238 miles of earth road improved by the state and 58 miles by counties.

It is proposed to carry over for construction in 1929, 422 miles of pavement of which 27 miles of concrete and 5 miles of gravel will be built by the counties but under state supervision.

The average cost per mile of concrete roads including cement for all widths is $29,609.96. The average cost per mile of earth grading of 32, 35½ and 41 ft. widths is $13,817.20.

The average width of the state roads is 18 ft., although some 20-ft. and 40-ft. roads have been built in the metropolitan area surrounding Chicago. The average thickness is 6 in. in the center with 9 in. at the outside edges except in the metropolitan area, when the thickness is 7 in. with a correspondingly heavier edge design.

Frank T. Sheets, Springfield, Ill., is chief highway engineer.

Indiana

In the fiscal year of 1928 Indiana built 228 miles of concrete and 109 miles of non-rigid bituminous pavement. The total expenditures were $16,616,554.

Present plans call for the building of approximately 250 miles of rigid type, 100 miles of non-rigid type, and the expenditure of approximately $18,000,000.

William J. Titus, Indianapolis, Ind., is chief engineer, State Highway Commission.

Wisconsin

The state highway work completed in 1928 included 303 miles of concrete, 190 miles of gravel and 217 miles of graded and drained road. Details of this work are given in the table that follows:

Wisconsin State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost Per Mile
Concrete	303	20	9-6½-9	$30,191
Gravel	190	26	5	3,400
Graded and drained	217	30	....	8,043

Very little incompleted state highway work was carried over to 1929.

The program for 1929 will be about the same as that of 1928.

W. C. Buetow, Madison, Wis., is state highway engineer.

Michigan

Over 545 miles of state highway work were completed in Michigan in 1928. This included 345 miles of concrete. Some details of the 1928 work are given in the table below.

Michigan State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Average Thickness In.	Average Cost Per Mile
Concrete	345.1	20	9-7-9	$40,969
Sheet asphalt concrete base	.1	36	9½*	62,067
Sheet asphalt gravel base	31.3	18	3†	23,370
Bit. macadam	2.98	20	8‡	32,673
Gravel	90.8	18	8§	13,838
Graded and drained	75.3	....	....	7,305

*7 in. base, 2½ in. top. †3 in. top. ‡5 in. base, §3 in. top.

The incompleted state highway work carried over to 1929 was:

	Miles	Probable Expenditure
Plain concrete	195.331	$7,800,000
Sheet asphalt conc. base	3.768	90,000
Sheet asphalt gravel base	26.965	650,000
Gravel	91.966	1,380,000
Graded and drained	55.503	400,000
		$10,320,000

The new state highway work proposed for 1929 calls for a probable expenditure of over $17,170,000, as follows:

New State Highway Work Proposed in 1929

	Miles	Probable Expenditure
Concrete	355	$14,200,000
Sheet asphalt gravel base	30	720,000
Gravel	100	1,500,000
Graded and drained	75	750,000
		$17,170,000

Frank F. Rogers, Lansing, Mich., is state highway commissioner.

West North Central States

Minnesota

During 1928 a total of 683.7 miles of state highway was completed in Minnesota. This included 113 miles of concrete, 297 miles of gravel and 273 miles of graded and drained road. Detail of the 1928 work follow:

Minnesota State Highway Work Complete in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost Per Mile
Reinforced concrete	113.1	20, 27	7-9-7	$27,000
Gravel	297.9	32, 40	.....	1,850
Graded, drained and bridges	272.7	32, 40	.....	14,400

The program for state highway work in 1929 has not been decided.

The following are average unit prices on contracts awarded for 1928 construction:

Earth excavation per cu. yd.	$ .29
Loose rock excavation	.56
Solid rock excavation	1.06
Overhaul per station yard	.0148
Hand ditching per cu. yd.	.48
Concrete in monolithic culverts per c.y.	19.46
Reinforcing steel per lb.	.0476
Installing 15 in. portable culverts, lin. ft.	.27½
Installing 18 in. portable culverts, lin. ft.	.32
Installing 24 in. portable culverts, lin. ft.	.41
Installing 30 in. portable culverts, lin. ft.	.74
Installing 36 in. portable culverts, lin. ft.	.63
Installing 42 in. portable culverts, lin. ft.	1.00
Installing culverts, 24 in.	.53
Installing 30 in. culverts	.61½
Installing 36 in. culverts	.77
Hauling culverts, per ton mile	.64
Gravel surfacing:	
Stripping, per cu. yd.	.22
Screening	.02
Screening and crushing	.55
Loading	.19
Hauling, per cu. yd. mile	.17
For concrete pavements per	
Sq. yd. using crushed rock aggregate	1.25½
Using gravel aggregate	1.39
These prices do not included cement.	
Fine grading, per cu. yd.	.72
Sloping or integral curb per lin. ft.	.087

J. T. Ellison, St. Paul, Minn., is chief engineer, state highway department.

North Dakota

During 1928 the state highway work completed included 425 miles of gravel road, 10 miles of sand-clay and 560 miles of graded and drained road. The incompleted state highway work carried over to 1929 comprised 470 miles of gravel road and 630 miles of graded and

drained road. The program for 1929 has not yet been adopted.

H. C. Frahm, Bismarck, N. Dak., is chief engineer, state highway department.

Iowa

On Nov. 6 the citizens of the state authorized a bond issue of $100,000,000 for the improvement of the primary road system. It is proposed to complete the work within a 6-year period. The work to be done includes 3,424 miles of paving at an estimated cost of $28,000 per mile, 720 miles of gravel road at an estimated cost of $4,000 per mile and 727 miles of grading at an estimated cost of $16,000 per mile.

Missouri

State highway work completed in 1928 comprised 171 miles of gravel surfacing, 107 miles of 18 ft. concrete, 12 miles of 9 ft. concrete and 186 miles of graded earth road.

In 1929 it is expected to build 216 miles 18 ft. concrete road, 15 miles 9 ft. concrete road, 139 miles gravel surfacing and 448 miles graded earth road.

T. H. Cutler, Jefferson City, Mo., is chief engineer, state highway commission.

Nebraska

State highway work completed in Nebraska in 1928 included approximately 500 miles gravel road, 250 miles grading and drainage structures, involving an expenditure of about $4,000,000. The probable mileage and expenditures for 1929 are as yet indefinite due to meeting of state legislature and probable change in highway revenue.

A. T. Lobdell, Lincoln, Neb., is chief, bureau of roads.

Kansas

During the fiscal year ending June 30, 1928, a total of 950.9 miles of state highway work was completed, the cost of the work being $8,308,205. The work included 437.4 miles earth road and culverts, 414.4 miles gravel roads, and 99 miles hard surfaced road.

The probable 1929 construction includes the completion of 150 miles of hard surfaced roads, 800 miles of sand-gravel and probably 500 miles of grading work. The construction expenditure will be about $8,000,000.

W. V. Buck, Topeka, Kan., is state highway engineer.

South Atlantic States

Delaware

During 1928 a total of 47 miles of state highway was completed. This included 28 miles of 16 ft. plain concrete road 8 in.-6 in.-8 in. thick, at an average cost of $24,000 per mile, and 19 miles of sand-asphalt road, 14 ft. wide and 6 in. deep at an average cost of $21,000 per mile. In addition 18 miles of concrete road carried over from the 1927 season were completed.

The program for 1929 has not been decided upon, but it probably will be about 50 miles, mostly concrete, with an expenditure of approximately $2,225,000.

The average unit bidding prices on the principal items in the 1928 work were:

Excavation	$ 0.90 per Cu. Yd.
Cement concrete pavement	12.00 per Cu. Yd.
Class A concrete masonry	25.00 per Cu. Yd.
Reinforcement	.07 per Lb.

C. D. Buck, Dover, Del., is chief engineer State Highway Department.

Maryland

A total of 144.8 miles of state highway were completed in 1928. In addition 103 miles of concrete shoulders 3 ft. wide were built on each side of existing roadway. The following table gives some details of the 1928 work:

Maryland State Highway Work Completed in 1928

	Miles	Average Width Surfaced Feet	Thickness Inches	Average Cost per Mile
Plain concrete	106.4	16	9-6.3-9	$ 30,000
Sheet asphalt	2.9	40	3	157,000
Bituminous macadam	6.95	16	8	20,200
Gravel	28.6	16	8	9,000
Concrete shoulders	103.12	*	8	11,200

*Three feet each side existing roadway.

The incompleted state highway work carried over to 1929 was as follows:

Incompleted State Highway Work Carried Over to 1929

	Miles	Probable Expenditure
Brick	0.45	$ 39,870
Plain concrete	47.38	1,421,400
Concrete shoulders	5.90	66,080
Bituminous macadam	9 87	199,374
Gravel	17.19	154,710
Graded and drained	4.21	36,627

The new highway work proposed for 1929 is as follows:

	Miles	Probable Expenditure
Plain concrete	75	$2,250,000
Sheet asphalt	5	785,000
Bituminous macadam	15	303,000
Gravel	30	270,000
Concrete shoulders	100	1,120,000

John N. Mackall, Baltimore, Md., is chairman and chief engineer of the State Roads Commission.

Virginia

The state highway work completed on June 30, 1928, the end of the fiscal year, includes 638.5 miles, 18 ft. wide, 8-6-8 in. concrete; 10.1 miles, 18 ft. 6 in. base, 1½ in. top, sheet asphalt; 3.2 miles, 18 ft. wide, 8 in. thick bituminous concrete; 1,796 miles, 18 ft. wide, 6 in. base, 2 in. top, bituminous macadam; 773.2 miles 20 ft., 10 in. thick, gravel road; 1,066.9 miles, 20 ft. wide, 10 in. thick sand-clay and soil road; 332.1 miles, 32 ft. wide graded and drained road.

The incompleted state highway work carried over to 1929 includes 85.3 miles plain concrete road; 136.1 miles bituminous macadam, 43.1 miles gravel road, 49.4 sand-clay and soil road and 75 miles graded and drained road. The contract or allocation for the above work amounts to $11,504,191; the amounts paid to June 30, 1928, amounts to $7,192,230, and the balance to be paid in 1929 is $4,311,962.

The program for 1929 calls for an approximate expenditure of $8,000,000.

C. S. Mullen, Richmond, Va., is chief engineer, state department of highways.

West Virginia

The state highway work completed in 1928 included 38.75 miles of concrete, 2.97 miles of brick pavement, 46.12 miles of bituminous macadam, 36 miles of gravel road and 148 miles of graded and drained road. Some details of this work are given in the accompanying table:

West Virginia State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost Per Mile
Brick	2.97	18	9	$29,824*
Plain concrete	38.75	18	7	33,638†
Bit. macadam	46.12	16	11	27,000†
Gravel	35.99	18	8	5,500†
Graded and drained	148.00	26	..	17,000

*3 in. brick on 6 in. concrete. †Paving only.

The incompleted state highway work carried over to 1929 comprised 6.49 miles concrete requiring a probable expenditure of $170,000; 9.16 miles bituminous macadam requiring a probable expenditure of $275,000 and 49.89 miles graded and drained road requiring a probable expenditure of $425,000.

No definite program as to the new state highway work for 1929 can be formulated until after the meeting of the legislature in January. It seems virtually certain, however, that the sum available will aproximate $10,000,000 and that the first lot of contracts will be let in March. The 1929 work will probably include about 250 miles of paving and 220 miles of grading.

The unit prices in 1928 on the principal items were as follows:

Unclassified excavation, low 37 ct., high 90 ct., average about 56 ct.; concrete pavement, low $10.25, high $14.00, average about $12.75; metal reinforcement for structures from 4½ to 10 ct., average 7 ct.; metal longitudinal joint, 13 to 17 ct., average 15 ct.; brick pavement $2.00 to $2.40; rock asphalt pavement, $1.79 to $2.25; bituminous macadam surface course, low 60 ct., high $1.25, average about $1.00; oil asphalt, 19 to 25 ct.; Bermudez 28 to 34 ct. Tar, 19 to 27 ct.; broken stone base, $3.50 to $5.80, average about $4.35; wire rope guard rail, 49 to 75 ct., average about 60 ct.; class A concrete used in road work, low $13.40, high $30.00, average about $19.00; class B concrete used in road work, low $10.92, high $25.00, average about $15.00; class A

concrete for bridges, average $21.00; class B concrete for bridges, average $15.30; steel reinforcement for bridges, average 6 ct.; structural steel for bridges, erected, average .068 ct.

C. P. Fortney, Charleston, W. Va., is chairman state road commission.

North Carolina

Approximately 1,175 miles of state highway work were completed in 1928, of which about 335 miles were hard surfaced, 380 miles oil treated and the balance progressive type of construction. About $15,200,000 was expended in 1928. It is estimated that about $9,000,000 will be expended in 1929.

L. R. Ames, Raleigh, N. C., is state highway engineer.

South Carolina

During 1928 a total of 420 miles of paved state highway was completed and 250 miles of other types. The incompleted work carried over to 1929 included 115 miles of paved highway, involving a probable expenditure of $3,150,000, and 50 miles of other types calling for an expenditure of $350,000.

The new state highway work proposed for 1929 calls for 350 miles of paved road, calling for a probable expenditure of $9,625,000, and 150 miles of gravel, sand clay and graded and drained road, calling for a probable expenditure of $1,125,000.

Charles H. Moorefield, Columbia, S. C., is state highway engineer.

East South Central States

Kentucky

The state highway work completed in 1928 includes the following:

	Miles
Graded and drained	433
Gravel roads	166
Traffic bound macadam	76
Waterbound macadam	35
Bituminous macadam	76
Rock asphalt	23
Reinforced concrete	59

The expenditures in 1928 for construction amounted to $10,000,000 and the total expenditures for the year totaled $13,800,000.

The probable mileage of new highway work for 1929 is 800 and the probable expenditure $13,000,000.

J. H. Watkins, Frankfort, Ky., is state highway engineer.

Mississippi

State construction expenditures in 1928 amounted to $2,800,000. The expenditures for 1929 probably will be about the same as in 1928. The probable expenditures by counties in 1929 in highway work total $1,500,000.

The mileage completed in 1928 includes the following:

	Miles
Graded and drained	87
Gravel surfacing	112
Concrete pavement	55
Bridge projects	2

The mileage prepared for 1929 is as follows:

	Miles
Graded and drained	150
Gravel surfacing	45
Concrete pavements	15
Bridge projects	3

A total of 4,800 miles of highway was under maintenance on Jan. 1, 1929, and the estimated expenditure in 1929 for this work is $2,400,000.

G. A. Draper, Jackson, Miss., is state highway engineer.

West South Central States

Oklahoma

State highway work amounting to 1,260 miles and involving a total contract price of $15,950,584 was completed in 1927 and 1928. The accompanying table gives some details of this work:

Oklahoma State Highway Work Completed in 1927-1928

	Miles	Average Surface	Width	Top and Base Thickness	Total Cont. Price
Brick	3.9	2½ in.	*18 ft.	7½ in.	$ 139,733
Plain concrete	213.9	..	18 ft.	6 in. (Bates)	5,136,295
Rock asphalt	85.3	2 in.	*18 ft.	7 in.	2,358,512
Gravel maintenance	152.7	..	---	4 in.	243,003
Graded and drained	800.1	..	..	..	4,262,964
Bridges	3.7	..	18 ft.	..	3,801,610
Miscellaneous	0.5	..	30 ft.	..	8,464
Total	1,260.2				$15,950,584

The incompleted state highway work carried over to 1929 included the following:

	Miles	Probable Expenditure
Brick	.....	$ 4,792
Plain concrete	66.2	1,474,582
Rock asphalt	54.9	1,442,237
Graded and drained	310.7	1,777,252
Bridges	2.8	1,003,352
		$5,702,217

New state highway work calling for a probable expenditure of $7,500,000 is proposed for 1929. The types and mileages are as follows:

	Miles	Probable Expenditures
Brick	5.0	$ 160,000
Plain concrete	70.0	1,500,000
Rock asphalt	60.0	1,800,000
Gravel maintenance	150.0	300,000
Graded and drained	400.0	2,000,000
Bridges	4.5	1,600,000
Miscellaneous	10.0	140,000
		$7,500,000

Clark R. Mandigo, Oklahoma City, Okla., is state highway engineer.

Texas

Approximately 1,000 miles of state highway were completed in 1928, at a cost of about $22,000,000. The construction program for 1929 will be about the same as was the one of the previous year.

The accompanying tabulation gives some details of the work completed during the fiscal year ending Sept. 1, 1928.

Texas State Highway Work Completed Fiscal Year Sept. 1, 1927 to Sept. 1, 1928

	Miles	Average Width, Feet	Average Thickness, Inches	Total Expenditure
Grading and drainage structures	648.26	28	.....	$3,794,668
Gravel or macadam	126.28	18	10	1,426,785
Surface treatment on gravel or macadam	19.79	18	¾ & 10	159,779
Asphalt pavement on gravel or macadam	312.38	18	2¾ & 10	4,293,387
Asphalt pavement on concrete	23.52	18	2 & 6	609,870
Concrete pavement	245.24	18	6	7,396,226
Bridges and approaches	3.68	24	.....	1,678,035

The incompleted state highway work carried over to 1929 was as follows:

	Miles	Total Expenditure
Grading and drainage structures	607.19	$3,865,560
Gravel or macadam	63.38	876,944
Surface treatment on gravel or macadam	131.45	927,671
Asphalt pavement on gravel or macadam	120.03	1,760,952
Asphalt pavement on concrete	9.69	234,745
Concrete pavement	364.66	8,717,048
Bridges and approaches	3.36	1,422,110

Gibb Gilchrist, Austin, Tex., is state highway engineer.

Arkansas

State highway work completed in 1928 included 620 miles grading, 287 miles gravel surface, 87 miles concrete and 6 miles asphalt. The mileage under contract includes 1,010 miles grading, 480 miles gravel surfacing and 18 miles concrete. The expenditures and obligations amount to $21,358,000.

C. S. Christian, Little Rock, Ark., is state highway engineer.

Mountain States

Idaho

During 1928 a total of 534 miles of state highway work were completed. This included 5 miles of concrete, 170 miles of gravel and rock road and 116 miles of graded and drained road. The mileage and cost of the 1928 work are shown in the accompanying tabulation:

Idaho State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost Per Mile
Concrete	5	20	9-6-9	$31,478
Bituminous Macadam	23	20 -	6 -	15,241
Gravel or Crushed Rock	170	18	6	9,126
Graded and Drained	116	24	.....	9,300
Bituminous Treatment	220	20	2½	1,751

The incompleted state highway work carried over to 1929 included 26.5 miles gravel road, involving a probable expenditure of $293,000, and 25 miles of graded and drained road, calling for a probable expenditure of $310,000.

The new state highway work proposed for 1929 includes 200 miles gravel or crushed rock road, calling for a probable exenditure of $2,500,000, and 300 miles of bituminous calling for a probable expenditure of $1,000,000.

The average contract unit prices on 1928 work were as follows:

Excavation—Solid Rock	Cu. Yd.	$ 1.26
Excavation—Loose Rock	Cu. Yd.	.58
Excavation—Earth	Cu. Yd.	.31
Excavation—Unclassified	Cu. Yd.	.68
Cement Concrete, Class "A"	Cu. Yd.	27.71
Cement Concrete, Class "B"	Cu. Yd.	23.90
Portland Cement Concrete Paving	Sq. Yd.	1.96

Surfacing Screened Gravel	Cu. Yd.	1.53
Surfacing Crushed Gravel or Crushed Rock	Cu. Yd.	1.62
Metal Reinforcing	Lbs.	.06
Loose Rip Rap	Cu. Yd.	2.05
Hand Placed Rip Rap	Cu. Yd.	4.67
Guard Rail	Lin. Ft.	.86
12 in. G. I. Pipe (Unload-haul-place)	Lin. Ft.	.38
18 in. G. I. Pipe (Unload-haul-place)	Lin. Ft.	.50
24 in. G. I. Pipe (Unload-haul-place)	Lin. Ft.	.73
30 in. G. I. Pipe (Unload-haul-place)	Lin. Ft.	.81
36 in. G. I. Pipe (Unload-haul-place)	Lin. Ft.	.93
18 in. Concrete Pipe (Unload-haul-place)	Lin. Ft.	1.50
24 in. Concrete Pipe (Unload-haul-place)	Lin. Ft.	2.00
30 in. Concrete Pipe (Unload-haul-place)	Lin. Ft.	2.33

J. D. Wood, Boise, Idaho, is commissioner of public works.

Colorado

The expenditures on state highway work in 1928 were approximately $6,000,000. It is probable that 200 to 250 miles of new work will be undertaken in 1929, and that the expenditures per unit will be about the same as in 1928.

L. D. Blauvelt, Denver, Colo., is state highway engineer.

Nevada

The accompanying tabulation shows some details of the state highway work completed in 1928:

Nevada State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost per Mile
Gravel	74.78	18	5*	$6,000
Graded and Drained reconstruction	104.91	18	5*	4,000
Bituminous treatment of gravel surface	106.74	18 & 20	3*	1,600

*Compacted.

The incompleted state highway work carried over to 1929 included 63.23 miles of gravel road involving a probable expenditure of $380,000, are 25.93 miles of reconstruction involving a probable expenditure of $103,000.

The following table shows the new state highway work proposed for 1929:

	Miles	Probable Expenditure
Gravel	94.73	$452,050
Reconstruction	95.06	446,374
Bituminous treatment of gravel surface	187.50	306,892

S. C. Durkee, Carson, City, Nev., is state highway engineer.

Arizona

The total budget for the present fiscal year (July 1, 1928, to June 30, 1928) is $8,194,889; however, approximately $2,813,481 represents the unexpended portion of the 1927-28 budget.

The 1927-28 budget provided for the construction of 100 miles of gravel surfaced highway, 239 miles graded and drained, 13.55 miles of pavement and 4,100 lin. ft. of bridges.

The 1928-29 budget provides for the construction of 83 miles of gravel surfaced highway, 16 miles graded and drained, 9.1 miles of pavement, 343 miles of oil surfacing and 4,981 lin. ft. of bridges.

The Arizona highway budgets are compiled for fiscal years; therefore the budget for the fiscal year (July 1, 1929 to June 30, 1930) has not been compiled.

W. W. Lane, Phoenix, Ariz., is chief engineer State Highway Department.

Utah

This state highway program for 1929 is as follows: Construction with federal aid $1,250,000 on 80 miles; oil-gravel 3 in. mulch, $470,000 on 138 miles; miscellaneous betterments, $280,000 on 82 miles; total $2,000,000 on 300 miles. Maintenance, $1,000,000 on 3,400 miles. About 5 miles will be paved.

H. S. Kerr, Salt Lake City, Utah, is chief engineer State Road Commission.

Wyoming

State highway work completed in 1928 amounted to 220 miles, the cost being $2,000,000. It is planned to construct the same mileage in 1929, the expenditures being approximately the same as in 1928.

Z. E. Levison, Cheyenne, Wyo., is state highway engineer.

Montana

During 1928 a total of 275 miles of highway was completed at a cost of about $3,500,000. The mileage of new work for 1929 will be about the same as in the previous year.

R. D. Rader, Helena, Mont., is state highway engineer.

New Mexico

The state highway work accomplished in 1928 included 200 miles Federal aid construction costing $2,700,000; 700 miles secondary state roads costing $900,000; 100 miles oiling gravel roads costing $300,000; maintenance of 5,300 miles of road at a cost of $1,250,000.

The 1929 program is estimated to be as follows:

Federal aid and Forest Roads, 147 miles, involving a probable expenditure of $1,900,000; oiling 350 miles, $1,250,000; state aid secondary roads, 350 miles, $350,000; 5,800 miles under maintenance, $1,500,000; county road work and maintenance, $500,000.

W. C. Davidson, Santa Fe, N. Mex., is state highway engineer.

Pacific States

California

A total of 313 miles of state highway was completed in 1928, the work including 112 miles paving, 167 miles grading and rock surfacing and 34 miles grading only. The expenditures were approximately $19,400,000.

The probable expenditures for 1929 will be at the rate of $2,000,000 per month. The construction program is prepared for biennial period commencing July 1 and it is impossible to estimate mileage until program is approved and appropriation made by legislature.

C. H. Purcell, Sacramento, Calif., is state highway engineer.

Oregon

The state highway work completed in 1928 included 100 miles of bituminous macadam, 75 miles of crushed rock road and 60 miles of graded and drained road. The average cost and mileage are given in the accompanying tabulation.

Oregon State Highway Work Completed in 1928

	Miles	Average Width Surfaced Ft.	Thickness In.	Average Cost per Mile
Bituminous macadam	100	18	2	$ 4,000
Crushed rock	75	18	10	7,000
Graded and drained	60	26	....	20,000

The incompleted state highway work carried over to 1929 included 30 miles crushed rock road involving a probable expenditure of $200,000 and 10 miles of graded and drained road involving a probable expenditure of $200,000.

The new state highway work proposed for 1929 is as follows:

	Miles	Probable Expenditure
Concrete	10	$ 300,000
Bituminous macadam	100	400,000
Crushed rock	50	400,000
Graded and drained	60	1,200,000

Roy A. Klein, Salem, Ore., is state highway engineer.

Washington

During 1928 a total of 263 miles of state highway was placed under contract. A total of 98 miles was completed. The sum of $6,590,000 was expended on all contracts. The program for 1929 will be approximately the same as in 1928.

Samuel J. Humes, Olympia, Wash., is State Highway Engineer.

Trees as Snow Breaks.—The effect of trees as permanent snow breaks to prevent drifting will be studied this winter by the forester of the Pennsylvania Highway Department, who will prepare a program for planting. Trees have been known to cut down frost action on paved roads through absorption of moisture at the roadside, and this feature will be observed also.

Highway Paving Job Controlled By Concrete Strength Specification

State of Tennessee Has Interesting Experience on 13-Mile Project

SCIENTIFIC control of the proportioning of concrete on a paving job pays, according to the experience of the Tennessee State Highway Department. This conclusion was the result of an interesting field experiment covering the paving of 13 miles of pavement laid near Murfreesboro, in Rutherford County, recently. The project was that known as Route 10, Project F.-A. 93-A.

Design of Mix.—The engineers designed a mix based on a compressive strength of 3,500 lb. per sq. in. at 28 days, using the regular cylinder compression test as the basis of laboratory inspection at first, and later ordering the apparatus necessary for making beam tests as more in line with modern practice. Gravel was secured from the Hardison Sand & Gravel Company, Nashville, Tenn., and at the beginning of the work the sand was obtained from Estill Springs. This sand had a fineness modulus of 2.30 and 40 per cent voids. The water-cement ratio specified was originally 0.7, or six gal. per sack of cement. With this aggregated the cement factor was found to run about 1.64.

Changed the Mix.—In order to obtain greater economy, the source of sand was changed, and sand obtained from the Paducah Sand & Gravel Company, thus obtaining a sand with a fineness modulus of 2.70 and 35 per cent voids. The mix was then adjusted to the basis of 1:2.25:3.53 and the water-cement ratio remained unchanged. Proportioning at all times was by weight. Tests then showed a cement factor of 1.35, which was in fact altered to 1.45 due to the effects of a low subgrade. Strengths were found to be so much higher than required that the water-cement ratio was then ordered changed to 0.8 in order to adjust the mix downward to the average required.

High Strengths Obtained.—Before the water-cement ratio was thus altered, strength tests showed a compressive strength of 2,797 lb. at 7 days and 4,729 lb. at 28 days for the first day's run, while the second day showed 2,930 lb. at 7 days and 4,891 lb. at 28 days, and the third day's run revealed strengths of 3,097 lb. at 7 days and 4,826 lb. at 28 days. This was for a mix designed for a strength of 3,500 lb. per sq. in. at 28 days, with a minimum allowable strength of 3,000 lb. at that age.

It is interesting to note that a similar job was done at about the same time using an arbitrary mix, and the 28-day strength tests showed an average strength at least 800 lb. lower and a poorer workability than on this job where the mix was controlled.

On this control job the strength of the concrete as shown by the test cylinders has not varied more than 10 per cent at any time. Moisture determination was made daily in the Chatellon flask, by dry rodded volume.

Construction Plant.—As shown in the photographs, the contractor used a batcher plant loaded by a power crane, and maintained a stockpile at this point. The batches were delivered to the paver by truck. A turntable was installed near the paver. The concrete was mixed in a Foote paver, and finishing was done with an Ord finisher. The finishing was followed by working the surface with a longitudinal float. After all finishing had been completed, a sunshade of canvas on a wheeled frame, running on the forms, was moved over the newly finished concrete. This prevented too rapid drying out of the concrete during the setting time. This curing step was then followed with covering the concrete with wet burlap and leaving this protective covering in place for 72 hours.

Those Responsible.—The work was done by the Municipal Paving Construction Co., of Nashville, of which W. D. Sessions is president and general manager, J. W. Frazee is vice-president, C. H. Simpson is secretary, and who were represented on the work by C. C. Crowell, superintendent. The State was represented by E. J. Hewitt, resident engineer, and H. O. Olsen, divisional materials engineer in charge of design, working under the direction of R. J. Love, division engineer. It is interesting to note, according to reports that have been made, that the use of this control of the mix resulted in no loss of operating time due to figuring out the mixes, and that the contractor was said to be enthusiastic about the results gained.

Lip Curb for Concrete Pavement

Lip curbs, to protect the earth shoulders of concrete pavements from erosion by the run-off of rain water, have been included in designs submitted for Federal Aid projects by four states—Georgia, Illinois, Iowa and Minnesota. These designs are shown in Fig. 1.

The lip curb, or edging, constructed on the top of the pavement, serves the purpose of carrying the rain water to the nearest offtake. It differs from the integral curb, or the curb and gutter, as its capacity is only sufficient for normal rainfalls, and the height—2 to 3 in. in 8 to 12 in.—is not sufficient to prevent traffic from running over the edge of the pavement.

The necessity for lip curb is determined by the character of the shoulder material and the grade of the pavement. It is usually not required in the heavier soils, such as clays, which do not erode as readily as silt or sand. Iowa, where the loess soil erodes readily, was one of the first states to submit lip curb on a Federal Aid project.

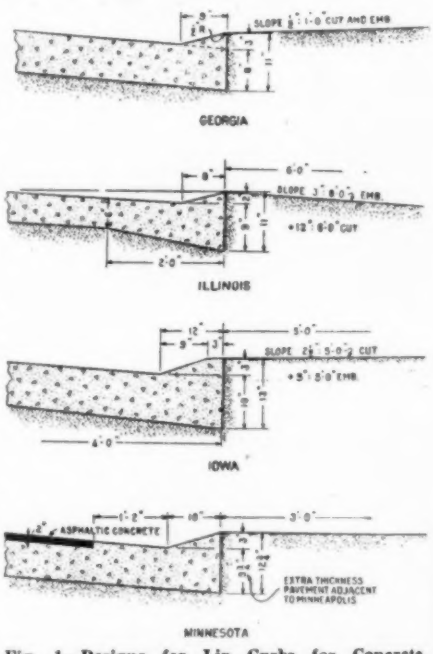
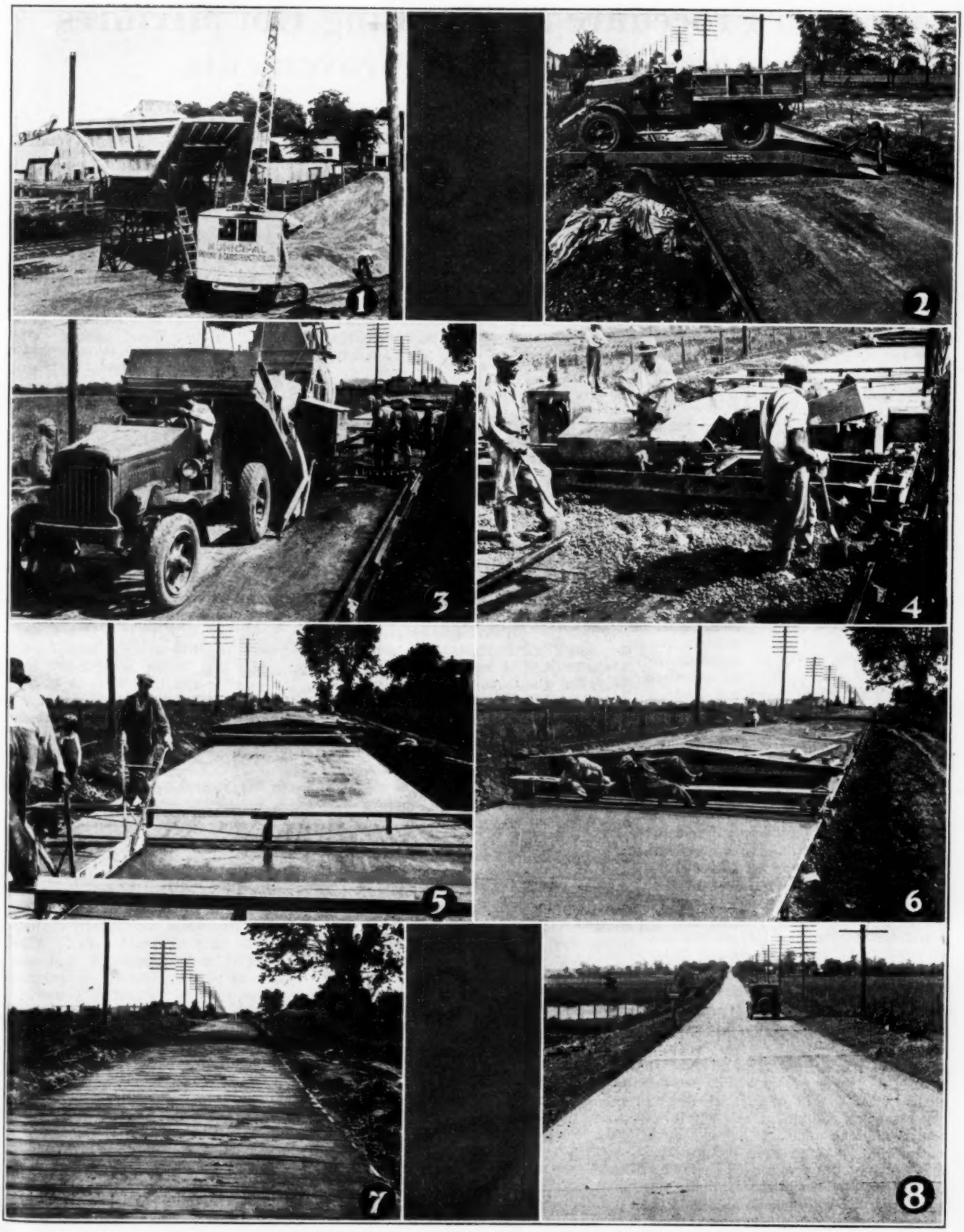


Fig. 1—Designs for Lip Curbs for Concrete Pavements

The lip curb is constructed immediately after the pavement proper has been finished. The side forms are raised to the required elevation, and then the extra concrete of the same mix as the pavement is spread next to the form and finished to the proper cross section with a float. In Georgia the corner is rounded with an edging tool. Offtakes are constructed at suitable locations, the design of the opening varying with the steepness of the roadway grade.

In both Illinois and Georgia the unit for payment is the lineal foot of lip curb. St. Clair T. Thomas, Associate Highway Engineer, U. S. Bureau of Public Roads, states in July Public Roads, that on one project in Illinois the price was 10 ct., and on a job in Georgia the cost was 4 ct. a lineal foot. In Minnesota and Iowa the cost is included in the unit price bid for the concrete pavement.



A Strength Specification Controlled This Job. 1—Batching Plant with Bin, Crane, and Stockpile. 2—Batch Truck on Turntable. 3—Batch Truck Dumping Batch Into Charging Skip of Paver. Note Sequence of Paving and Curing Operations. 4—The Finishing Machine at Work. 5—Longitudinal Float and Sunshade Used on the Job. 6—This Sunshade Was Used for Early Protection of the Concrete. It Moved on Wheels Along the Forms. 7—The Pavement Was Next Covered with Wet Burlap for 72 Hours. 8—View of the Completed Pavement

Chicago Procedure in Handling Hot Mixtures on Sheet Asphalt Improvements

Rakers Use Shoes with Stilt Pegs

By EDWARD N. EATON, B.S., M.Sc., Chem. E.
"Expert Asphalt Chemist," Board of Local Improvements, Chicago

THE construction of a sheet asphalt improvement is governed by fairly well standardized procedure. The aim is to build a pavement which will satisfactorily serve as a traffic artery in all seasons of the year during the natural life of the pavement. To do this the pavement must possess a smooth and even surface; retain its original contour and integrity; must not mark excessively in summer, either in the lines of traffic under moving vehicles or along the sides where heavy vehicles may be parked for a considerable length of time; nor crack in winter.

Temperature and particularly temperature changes are important factors in the longevity, serviceability and usefulness of an asphalt pavement. As the air temperatures in Chicago range from the extreme of 103 deg. F. above zero in summer to 23 deg. F. below zero in winter, meaning a much greater variation in temperature than this in the pavement itself, and as the temperature variation in a single day is often as much as forty or fifty degrees (sudden variations of temperature are particularly apt to be encountered in pavements adjoining Lake Michigan), the design of pavements in Chicago as regards thickness and the handling of the material on the street must be in conformity with these temperature conditions. The intensity of traffic as regards number, speed and weight of vehicles is also an important factor to be considered. As an aid in this connection we have the service record of asphalt pavements laid during the past forty years, and during the last twenty-two of those forty years all asphalt pavements have been laid under laboratory supervision and control.

For many years the standard type of sheet asphalt construction in Chicago was 6 in. of portland cement concrete, 1½ in. of binder and 2 in. of top. In 1925 this type of construction was changed to 6 to 8 in. of portland cement concrete, 2 in. of binder and 1½ in. of top. This was done on the reasonable assumption that greater compression and density of top would be secured in the lesser thickness, and if there was a difference in the compressibility of the thicker binder it would not be so much to the disadvantage of the pavement. The later type of construction has also an economic advantage in lesser cost of materials. This form of construction generally has proved satisfactory, and has lessened the tendency to the formation of waves and pushing. As regards the top, however, it is more difficult to rake to an even thickness, must be heated to a higher temperature than 2-in. top and is more apt to feather —crack and honeycomb, and the difficulties are accentuated in cold or windy weather.

As regards the handling of top and binder on the street, the aim is to spread to a stated and uniform thickness with uniform compaction, that is, where every square inch of base will support the same weight of binder and top, and to subject the mixture to compression while still in a hot and plastic condition. Several factors effect the compressibility and thickness of the material. One is the unequal compaction of the material—in truck, in dumping, in shoveling and in manipulation during raking. For this reason it is specified that all surface mixtures must be turned and distributed to the place where it is to be raked. For this reason also, the rakers are required to wear sandals equipped with lugs or pegs to elevate the wearer above the layer of surface mixture. This practice was introduced in Chicago at the instigation of Division Engineer Albert Schafmayer some 13 years ago. Several types of stilts were tried before one was designed which the rakers could be induced to wear. Another change over older procedure is in the substitution of twelve to fifteen-ton rollers for the initial compression of asphalt top for the five to eight-ton rollers formerly used. The beneficial effect of the twelve-ton roller in the initial rolling of Chicago, Topeka granitic asphaltic concrete was observed in 1915 and was used at that time and subsequently on both this type of pavement and sheet asphalt. In 1925 the use of a fifteen-ton tandem or a ten-ton three-wheel roller was made mandatory. The final compression must be effected with a tandem roller weighing not less than eight tons. Other things being equal, this procedure increases the density and decreases the voids in the asphalt surface mixture and leaves less compaction to be subsequently effected unequally by traffic. Motorization of trucks, rubber tired fire wagons and gasoline rollers are more or less recent innovations.

The average asphalt top gang in Chicago consists of twenty-five men. There are six asphalt rakers, six asphalt shovelers, two dumpers, two tampers, two smoothers, two street laborers, one cement and paint man, three roller men and one foreman.

The street is usually marked with a line down the center longitudinally, thus dividing it in two equal halves. The gang is also equally divided, each gang taking one half of the street and the two halves of the street are spread, raked and rolled simultaneously or nearly so. The street is measured and load marks made based on the amount of material which should be used to obtain the specified thickness for the type of pavement as directed from the laboratory. Of course the inspector on the street uses depth gauge to insure the required thickness uniformly.

All vertical exposed points of contact with gutters, manholes, and catchbasins are coated with a light application of asphalt cement to promote adhesion and aid in waterproofing. It is not considered good practice to cover binder with top while the binder is still hot and plastic, and generally binder is laid in the afternoon and topped the following morning. This procedure is particularly essential with the thicker binder—and even more so with black base used to reinforce foundations and bring to grade whether laid in one or two courses. The top is spread and raked to a uniform and fluffy surface in the manner heretofore described and as soon as practical thereafter it is compressed with the heavy roller moving longitudinally with the street and in the same manner into the alley wings. Wherever possible the street is also rolled horizontally or diagonally or in a diagonal curve. After the initial rolling, natural hydraulic cement or portland cement is broomed over the surface. Portland cement is more commonly used of late. One company practices an odd economy—having a room in which the empty cement sacks returned from use in other activities of the company are shaken to free them of adhering and residual cement, and an unbelievably large amount of cement recovered, which of course is quite suitable for this purpose.

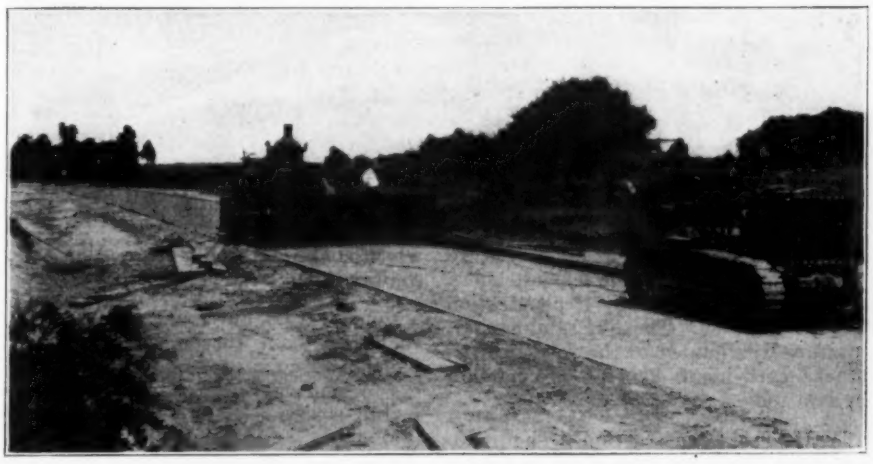
After the application of cement the final compression is effected by a tandem roller weighing not less than eight tons. Not less than two rollers and generally three rollers are used on the work. Skill is a necessary requisite in all the operations on the street and only experienced men are employed to perform this class of work.

Sand-Asphalt Construction on State Highways in Delaware

Methods and Costs of a Federal Aid Job

By W. E. ROSENGARTEN
Traffic Engineer, The Asphalt Association

IN many sections of Delaware, especially along the sea coast, sand abounds and other road building material is lacking. In such places frequently it has been found possible to use this local sand and bind it into a stable pavement by the use of asphaltic cement. In considering work of this nature it is first necessary to make a study of the available sand. The grading or proportioning of various-sized particles should be determined by passing the sand through sieves and if it is fairly uniform from coarse to fine and thus matches closely the grading of a so-called asphalt sand, it can be used for the construction of a satisfactory pavement. The usual limits of grading for a sheet asphalt sand are that 100 per cent shall pass a 10-mesh sieve (10 wires each way per inch), 14 to 50 per cent shall pass a 10-mesh sieve and be retained on a 40-mesh sieve, 30 to 60 per cent shall pass a 40-mesh sieve and be retained on an 80-mesh sieve, 16 to 40 per cent shall pass an 80-mesh sieve and be retained on a 200-mesh sieve, and not over 5 per cent shall pass the 200-mesh sieve. At times a beach or bank sand will run too coarse or too fine and will not be satisfactory unless it is possible to mix two sands in proper proportion so that combined product has a satisfactory grading which will compact to a stable paving mixture.



Asphalt Spreader Box on Job on Greenwood Road

Sand-Asphalt Federal Aid Project.—During the past summer there was under construction an 8.02 mile stretch of paving of the sand-asphalt type, known as Federal Aid Project No. 46, in Sussex County, Delaware, extending northeast from Greenwood toward Milford. This stretch is in a deep sandy rural country in the south-central part of the state, and, therefore, some type of surfacing utilizing this local material is highly desirable. While the main roads are paved, many of the secondary and connecting roads still require paving. The sand-asphalt pavement presents an inexpensive and highly desirable type for this purpose.

Grading Analysis of the Sand.—An analysis of sands along this project indicated that a satisfactory material was available at a very convenient point at the southwest end of the project near the edge of Greenwood and at the intersection of the railroad and the main State Route No. 13. A typical grading analysis of the sand, which matches closely the sheet asphalt grading limits, is as follow:

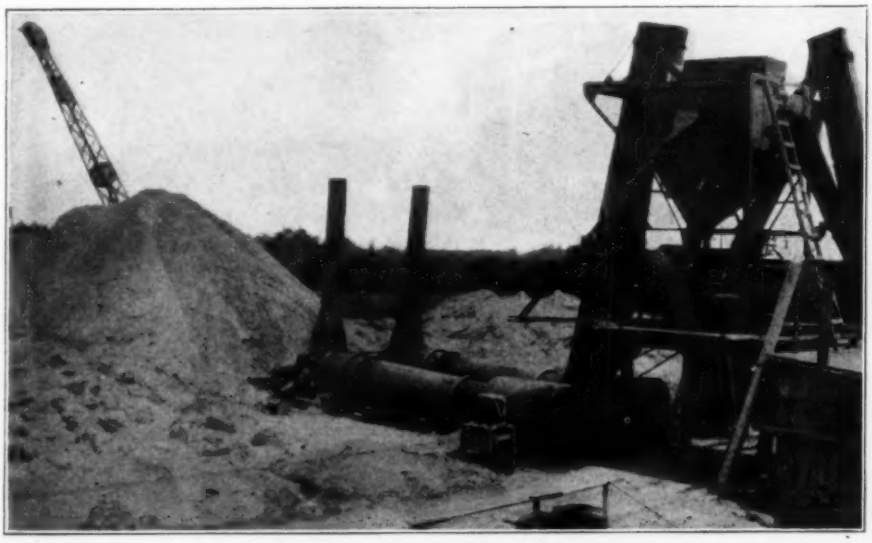
Passing 10-mesh sieve, 100 per cent.

Passing 10 retained on 40-mesh sieve, 33 per cent.

Passing 40 retained on 80-mesh sieve, 48 per cent.

Passing 80 retained on 200-mesh sieve, 17 per cent.

Passing 200-mesh sieve, 2 per cent.



Asphalt Plant Used to Build the Sand-Asphalt Pavement

The Paving Plant.—At the point mentioned above, the asphalt paving plant was set up and a crane installed to excavate the sand and pile it at the feed end of the driers. The plant has a capacity of 3,000 sq. yd. of 2 in. pavement per day. Two driers, heated by burning fuel oil in an internal combustion chamber, raised rapidly to the desired temperature an ample supply of sand. The mixer was of large capacity, handling 2,000 lb. batches. The power for operation of driers, mixers, etc., was supplied by an electric motor. Petroleum asphalt was received at the railroad siding in tank cars and pumped to a storage tank.

The Mixture.—The mixture used for the base was 1,860 lb. of sand and 140 lb. of asphalt cement, thus giving a bitumen content of 7 per cent. The surfacing mixture averaged 1,530 lb. of sand, 270 lb. of limestone dust, and 200 lb. of asphalt cement which gave a con-

Sand-Asphalt Laid in 1925 on Concord-Hardscrabbe Road

tent of 13½ per cent of filler and 10 per cent of asphalt. The asphalt had a consistency as shown by a penetration test of 40 to 50. The hot sand-asphalt mixture was hauled to the road in light trucks carrying a load of two batches or two tons.

Method of Construction.—The roadway was carefully shaped to the proper line and grade and forms consisting of 2 in. x 8 in. planking were securely staked in place. These were left in place for curbing to support the edges of the pavement. By the time they rot out the shoulders will have become sufficiently compacted to serve this purpose. Of particular interest on this work was the method used for spreading the hot sand-asphalt mix. The contractor had designed a very satisfactory spreader-box which spanned the entire 14 ft. width of the roadway. It rode on the wood form boards and was pulled forward by a tractor. The box was framed with heavy timbers and lined with sheet steel. Two angle irons extended the length of the box. When material was dumped from the trucks the angles had their flat faces horizontal and caught most of the load. They were mounted so that by means of a handle they could be tilted and thus drop gradually the material on to the subgrade and at the same time cut or break down any lumps that may have formed. The rear side of the box had a cutting edge shaped to the cross section of the roadway and struck off the mix to the proper depth so that when rolled it had the desired thickness and shape. This cutting edge was adjustable so that it could be set for either base or top. The spreader-box left the material with a smooth surface and since it spanned the entire width of roadway but little touching-up by hand was necessary prior to rolling. The roller was able to work close up to the spreading operation and good compaction was obtained. The thickness of the sand-asphalt base course was 4 in. after compaction and the wearing surface which contains the filler was 2 in. after compression.

Construction Force.—The plant gang consisted of a foreman, burner man, boiler man, mixer man, and four shovelers to feed the sand. It was planned to install a screw feed to the sand elevators which would reduce the four shovelers to one. The road gang was composed of a foreman, two roller men, one spreader box operator, one truck dumper, two tamper, two box rakers, and two surface rakers.

Output and Cost.—This outfit turned out an average of 1,000 to 1,100 ft. of 4-in. base per day and it was expected as the jobs became better organized to turn out daily 1,800 ft. of 14 ft. roadway base 4 in. thick. The length of top laid per day was double that of the base. The contract price for the 6 in. of mixed sand asphalt in place was $1.75 per square yard. The project, which was under the direction of John Hitchens, state district engineer, involved 66,000 sq. yd. of sand asphalt pavement and 26,000 cu. yd. of excavation, which, together with structures was let at a total bid of $160,251. The successful bidder on this project, the Highway Engineering and Construction Co., of Selbyville, Delaware, had previously built a considerable mileage of sand asphalt roadway in North Carolina and Delaware. J. G. Townsend was the superintendent in charge of the work.

Other sand asphalt projects in Delaware include five miles laid in 1925 on the Concord-Hardscrabble Road, east of Seaford and five miles, laid in 1926, east from Selbyville to Williamsville, as well as most of the streets in the town of Selbyville. These pavements were all inspected in 1928 and found in excellent condition.

The work in Sussex County, Delaware, on Federal Aid Project No. 46, demonstrates that it is possible at an expenditure of $20,000 per mile, to provide a smooth, easy riding boulevard in place of an almost impassable sand trail. Under average conditions the annual cost of providing this sand asphalt roadway can be taken at $1,000 for interest and $1,000 for depreciation and maintenance or a total per mile of $2,000. Thus it may be said that (2,000÷365 or) $5.50 per day would be the cost of perpetuating a mile of this improvement. It should be remembered that the original improvement includes the grading and base for future resurfacing so that the above estimate is quite liberal. Surely there are many roads through sandy sections on which traffic will justify an outlay of $5.50 per mile per day.

With a traffic of 275 vehicles per day, a toll of $0.20 will pay for a 10 mile stretch of improved roadway. The inevitable increase in traffic, with the improvement of the road and the passage of years, should show that an improvement of this kind is justified on unimproved roads having a traffic considerably less than 275 vehicles per day.

5-in. Sand-Asphalt Laid in 1926 on Williamsville Road

Developments in the Use of Tar in Highway Construction

Use of Tar in Road Construction and Maintenance

By WALTER BUEHLER,
Assistant Sales Manager, The Barrett Co., New York City

TO meet the rapidly changing traffic conditions in the past few years, much development work has been done both on the road tars themselves and also upon the methods under which they are used. In general it has been found possible to greatly extend the field of usefulness of these products by treating lower type roads and thus making available for the engineer new types of low-cost roads. By the use of these new and improved methods and materials the highway official can furnish dustless, safe road and street service to communities which a short time ago had to be content with mud and dust because they could not afford the initial cost of a high type, expensive surface.

Penetration Macadam. — Penetration macadam is a means between the high-cost surfaces referred to above and the low-cost roads to be described later. It has given an excellent account of itself as a street paving for a quarter of a century. One of the objections to this type has been its high labor cost. This has been reduced and the riding quality of the pavement improved by the use of stone spreaders for distributing the aggregate, graders and maintainers for spreading the stone and mechanical spreaders for the choke stone and the cover stone. Brooms are attached to the roller so that both the choke stone and the cover stone is uniformly distributed during the rolling processes.

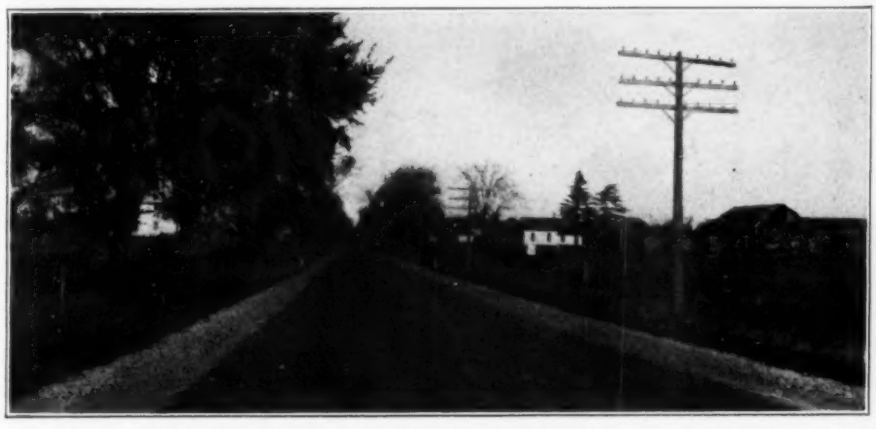
Changes in penetration macadam design have to date been confined to stone sizes and quantity of tar. While the usual size of stone specified for the penetration course using hard rock is still 1¼ to 2½ in, the minimum has been raised to 2 in. and the maximum to 3 in. or 3½ in. for soft rock. In order to more thoroughly fill the surface voids the average size of choke stone has been reduced from ¾ in. to ½ in. The amount of tar in the first seal coat has been increased from ½ gal. per square yard to ¾ gal. per square yard because of the high percentage of rubber-tired vehicles now found upon all streets.

Improved spreading apparatus makes it possible to obtain exactly the amount of tar specified per square yard. A new quick-closing valve assures the stopping of the tar distribution at the exact point desired with no over-run into the next section. Efficient oil heating apparatus keeps the tar at exactly the correct temperature for proper application. The proper temperature will vary with atmospheric conditions and stone sizes, but will not be above 275° F.

Cold Penetration Macadam.—A modification of the penetration macadam type called cold penetration macadam or puddled macadam has a place for residence streets or light traffic business streets. Briefly stated, it is built like waterbound macadam up to the point where the water is applied. A cold refined tar which will penetrate into the road and bind after it gets there is substituted for the water. The first coat of cold refined tar is applied at the rate of approximately ¾ gal. per square yard and immediately covered with a light coat of stone screenings and rolled. Within the next 24 hours an additional ½ gal. per square yard of the same material is applied, covered with stone chips or pea gravel, and rolled. This produces a somewhat more tightly bound surface than a waterbound macadam and is maintained by successive tar surface treatments.

There is still a very large yardage of waterbound macadam on our streets. Original tar surface treatments should always be made with a cold refined tar. For re-treatments the modern tendency is to use a hot surface treatment tar. The chief precaution to be observed is to keep the quantity of tar per square yard to a minimum. One-quarter gallon per square yard is the maximum amount which should be applied at one time and 1/6 or even 1/8 gal. per square yard will often give excellent results. Mechanical chip spreaders are quite commonly used for applying the cover stone.

Tarvia Re-Tread Pavement.—An entirely new type of macadam construction has been developed in the past few years and was named "Tarvia Re-Tread" by the Barrett Co. The name "Re-Tread" struck the popular fancy and has been applied to a number of modifications only remotely related to the original Re-Tread type. The type was developed in Pennsylvania to take care of shale surfaces which were strong enough to carry traffic but which could not always be successfully surface treated. As built in Pennsylvania it is essentially a penetration type. The road surface to be strengthened is smoothed up and approximately 2 in. of stone ranging in size from ½ in. to 1¼ in. distributed over it. This is given about ¾ gal. per square yard of refined tar having a specific viscosity of 30 to 35. The road is kept shaped up with a blade grader and a roller if available. At the end of three or four days the road is set up and is then given a second application of about ¼ gal. per square yard of the same grade of tar. This second application should be covered with stone chips or pea gravel, but sometimes it is not. The surface is finally shaped up with the roller.



Tarvia Re-Tread Near Adrian, Mich.

Extensive experience in various localities with this new type have resulted in some changes in the usual methods so that Tarvia Re-Tread is now essentially a mixed-in-place pavement. A special grade of tar sold under the trade name of Tarvia Re-Tread has been developed. This material sets up quick enough to shorten the construction time, but still remains plastic long enough so that the tar and stone may

be properly manipulated. The total amount of tar has not been changed, but the first ¾ gal. is put on in two applications about 24 hours apart. After each of the first two applications of tar, the tar and stone on the road is turned over with a blade grader, drag, or maintainer, so as to thoroughly mix the tar and the stone. When the tar of the second application becomes sticky or tacky the road is thoroughly rolled. A seal coat of ¼ gal. per square yards of the same tar is applied, covered with stone chips, or pea gravel, and rolled to the final finish. This method produces a non-skid, dust-

Tar Treated Gravel in Michigan

less, smooth riding street surface at a very low cost. It can be built over any foundation strong enough to carry the weight of the traffic and furnishes an easy solution of the paving problem for residence streets and light traffic business streets. It is maintained with successive surface treatments like waterbound macadam. If it shows signs of distress an additional Re-Tread top can be added for very little cost. It should be possible to build a Re-Tread surface in most localities for from 50 to 75 cts. per square yard.

Tar Surface Treatment of Gravel.—Methods for the surface treatment of gravel with cold refined tar have been developed until it is now possible to successfully treat almost any gravel street. Many municipalities have adopted tar surface treated gravel for their light traffic streets and give excellent paving service at a very low cost.

Tar surface treating gravel methods may be divided into two general classes —the straight surface treatments and the mulch or turn-over methods. Gravel streets containing a high percentage of large pebbles. Gravel streets containing a high percentage of large pebbles and which are solid enough to be swept successfully give the best results under the straight surface treating method. Cold refined tar is used, and it is applied to the clear road surface in two equal applications of about ¼ gal. per square yard each. There should be an interval of at least 24 hours between applications. The second application is covered with sand or fine gravel. The object of the treatment is to form a toughened crust of the original surface rather than a mat on top of it.

In the mulch method the loose gravel on the surface is bound together with cold refined tar and this tar-bound mat tightly fastened to the solid material underneath with additional tar. To obtain this result the loose mulch, which should be from 1 to 1½ in. thick, is sprayed with about ⅓ gal. per square yard of cold refined tar. This tar and gravel mixture is then moved with a blade grader from one side into a windrow near the center of the road and the solid material underneath treated with about ⅓ gal. per square yard of cold refined tar. The tar gravel mixture in the windrow is graded back over the wet tar, and the operation repeated on the other side of the street. The grader, drag, or maintainer is kept working on the street until the tar sets up. A light seal coat may be necessary to thoroughly close up the surface.

The surface treatment of gravel streets is a maintenance operation, and holes which may appear in the early life of the treatment must be immediately patched. Successive but not necessarily annual surface treatments with cold or hot refined tars will keep the streets in good shape.

Expensive pavement surfaces often become very slippery. A light surface treatment with cold or hot refined tar and suitable stone chip, pea gravel or granulated slag cover will cure this condition. Tar surfaces are always non-skid surfaces.

Tar cut back material for preparing cold patch tar concrete has been improved until there is less of it required per cubic yard of aggregate than of any other bituminous binder used for the same purpose.

In general the road tars and their methods of use have been developed from year to year so as to make it possible for the highway engineer and official to give the public more miles of better roads and streets for less cost per mile.

Acknowledgment.—The foregoing is a paper presented at the last annual meeting of the American Society for Municipal Improvements.

Fatal Accidents Bring Suspension of Operators' Licenses in Pennsylvania

Secretary of Highways James Lyall Stuart has announced that any driver who is involved in a fatal accident will have his driver's license suspended immediately. The law provides that in all cases of suspension of driver's license, which includes fatal accidents, the suspended operator will be given a hearing, on request, and if the facts reveal that the driver was not responsible, his driving privilege will be restored.

Secretary Stuart said: "The alarming number of fatal accidents makes this drastic action necessary. This is particularly vital in view of the fact that fatalities, resulting from automobile accidents reported to the Department of Highways, jumped from 77 in September to 112 in October. The 112 fatalities in October become more striking in view of the fact that in the preceding nine months in 1928 the number of automobile fatalities in Pennsylvania totaled 513. In other words, the automobile death list in October was equal to one-fourth of the fatal casualties in the nine months preceding it.

"The records of the Pennsylvania Department of Highways from 1924 to 1928 show that October heretofore has had the lowest relative accident hazard of any month of the year. October, too, is the month that signalizes the decline of seasonal vehicular traffic and the enormous increase in fatalities demands that positive action be taken to reduce the fatal accident toll.

"The reports of the Bureau of Vital Statistics, Department of Health, point to a greater death toll than that reported to our Bureau of Motor Vehicles, under the compulsory accident report law, indicating that many motorists are neglecting to or refusing to report accidents, as required by law. Steps have been taken to secure the cooperation of the Bureau of Vital Statistics with the Bureau of Motor Vehicles in the matter of accident reports and one of the first results will be the prosecution of persons neglecting to file such reports. The second step will be the coordination of the statistics of the two bureaus to insure a full and accurate compilation of accident statistics."

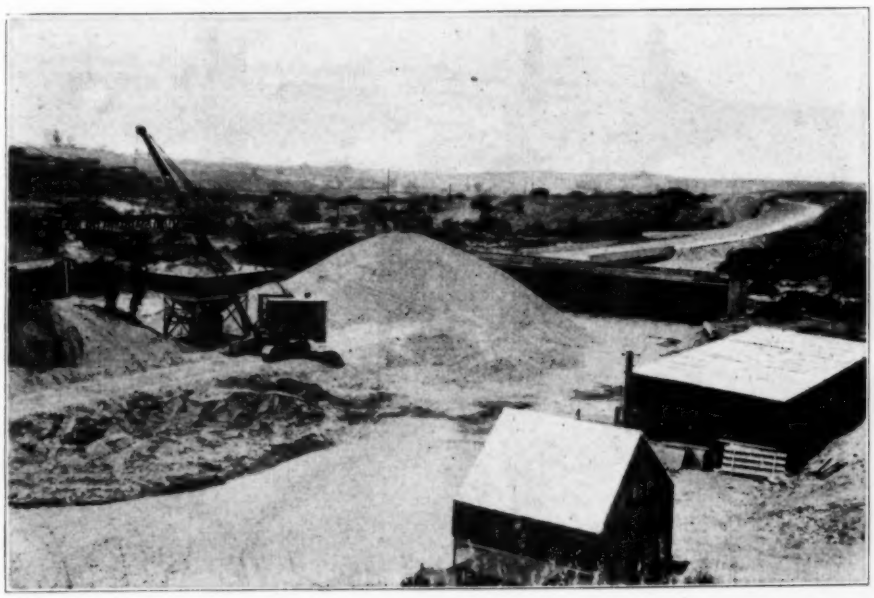
Paving Major Arterial Highways at San Diego, California

Providing Adequate Transportation Facilities from City to New District

By E. L. FREELAND,
President and General Manager, Roy D. Keyes Engineering Organization, Inc.

WITHIN the last two years, three major arterial highways have penetrated the area east from San Diego, making accessible a large district highly suitable for residential development. Each of these highways was paved with concrete. The last of these highways so constructed was the Market St. extension, an 8½-mile project, formally opened on Aug. 11. We are indebted to the January Concrete Highways for the following account of the work:

Starting at 25th and Market Sts., San Diego, the concrete pavement is 68 ft. wide for about one mile, then 40 ft. in width for 1½ miles; the balance is 30 ft. wide for three miles and 20 ft. for the remaining three miles. These widths are in accordance with the estimated potential traffic volume. The selection of cement concrete pavement for the improvement was made upon a majority petition of the property owners in the assessment district which carries the levy for the work.



Fine and Coarse Aggregate Secured Locally Were Hauled to a Central Proportioning Plant Where Materials Were Batched by Weight

Work Let as One General Contract.—Under the Mattoon Act, California's newest street improvement law formerly known as the Acquisition and Improvement District Act of 1925, the proceedings for opening, widening, underground and surface improvement were grouped and let under one general contract.

This contract which was awarded in November, 1927, to E. Paul Ford of San Diego provided for extension of the sidewalks, curbs, sewer and water lines in the sections not already so equipped, six major bridges on the arterial thoroughfare, and the paving which totaled 1,593,000 sq. ft. of cement concrete having a thickness of 6 in. with edges increased to 9 in.

Grading Work.—Preliminary grading, sidewalk and curb construction, underground work and the bridge construction were let to sub-contracts. A portion of Market St. had been brought to grade some years before; however, a large job remained. This involved about 114,000 cu. yds. of excavation and 66,000 cu. yds. of embankment. Indicating the speed which attended the work, the contractor had five steam shovels and at least 300 head of stock on the grading at one time. With efficient planning the preliminary work was kept well in advance of the paving operations. One feature of this part was the regular bi-monthly meetings of engineer, general contractor and subcontractors to plan and cooperate so that each division of the work would be handled coordinately with the others.

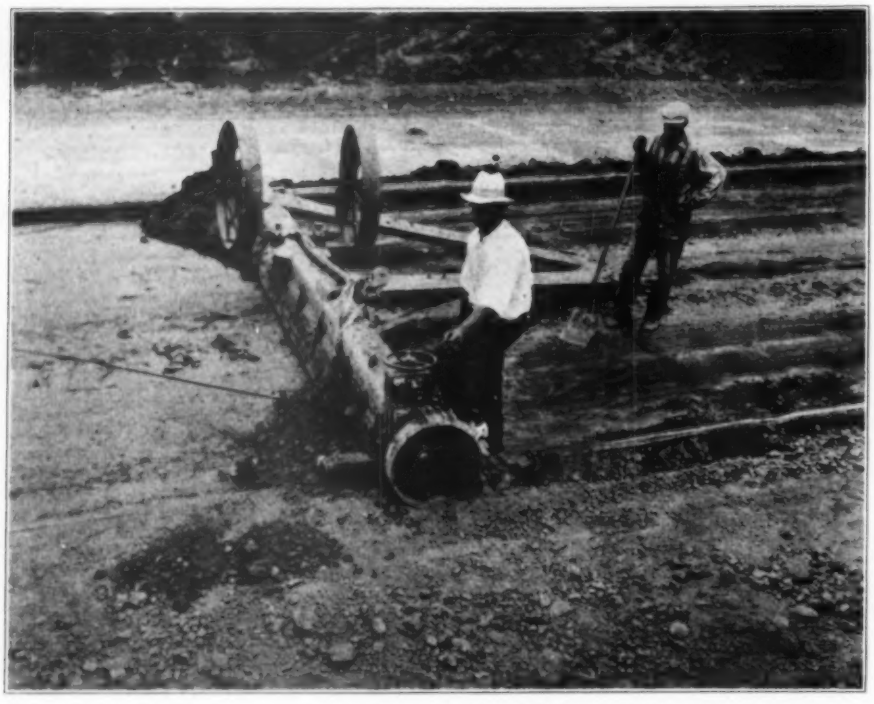
Concrete pipe was used extensively in the underground systems. Six and eight-inch sanitary sewers of concrete were placed, there being a total of 26,180 lin. ft. House connections were all made with 4 and 6-in. concrete pipe; a total of 4,580 ft. of these were placed. In addition there were 3,275 ft. of concrete culvert pipe ranging in sizes from 18-in. to 72-in.

Bridges.—The six bridges on the project were from 68 ft. to 19 ft. in span length. Roadway width were in conformation to the pavement width requirements and ranged from 68 ft. to 30 ft. Four of the six bridges were on new locations; the expansive Twenty-eighth street structure and the Chollas Creek Bridge replaced old concrete bridges at the same locations. An attractive design was selected with architectural treatment confined to paneling

View of New Pavement and Character of Country Traversed by It

and bush hammer decoration. Specifications provided for a well graded concrete to prohibit rock pockets and careful form work resulted in an excellent surface.

The general contractor placed the concrete paving. Needless to say that this work on the large scale required the best in organization and equipment. That his efficient management was well supported is evidenced by the fact that the entire job was finished nearly five months ahead of the time provided in the contract.



Subgrader Used by the Contractor. The Crown Template Is Bolted to the Front of the Beam. In Moving, the Machine Is Turned Over and Rolled on the Large Wheels Above the Center. A Tractor Pulls the Machine

Paving Materials.—The materials for the entire paving yardage were batched from one plant set-up situated near the middle of the job. Aggregates were produced locally, the plants providing these being located not more than four miles away. The sand and gravel were trucked to the contractor's storage yard and stockpiled. Careful grading analyses were made and two sands were combined to give the required grading, one of them being somewhat deficient in fines. All sand was washed. The batching plant provided for the proportioning of aggregates by weights, thereby eliminating many of the inaccuracies possible with volumetric measurement.

Specifications called for a mixture of six bags of cement per cubic yard of concrete, which with careful water control, resulted in uniformly high strength concrete. The one mixer, a 27E, made concrete for the entire job. Trucks hauled from the batching plant direct to the mixer which ran on the grade. Cement was dumped from the sacks which were stored in advance along the right-of-way.

Construction Features.—After concrete was run from the mixer upon the carefully rolled subgrade, it was struck off and preliminarily finished with mechanical machines, followed by longitudinal and transverse hand floats and finally belted. The belts on the last part of the work were attached to bow frames, and this equipment was thought to be very efficient. Joint practice followed the most modern developments including the use of "weakened plane" joints between expansion joints. The expansion joints running transversely were spaced at 60-ft. intervals with the weakened plane or "dummy" surface joints, 2-in. deep, placed at the 20-ft. points between the full joints. Premolded filler was used in the through joints and the weakened plane joints were poured with filler the day following the placing of the pavement, and before the earth cover used for curing was spread. In order to get on the new concrete so quickly, a rubber tired tar wagon was used. The strip widths for the wide pavements were so arranged to make uniform appearance with a minimum of changes in equipment.

The riding surface of the concrete is especially good and has occasioned much comment from motorists who are using the road. Adherence to the specifications with care in workmanship and inspection promoted good feeling throughout the duration of the construction and has produced a pavement of high quality. Through organization and good equipment on the part of the contractor was of material worth in pushing the job through in record time.

Sub-contractors were: H. G. Fenton, grading; O. U. Miracle, sidewalks and curbs; Stroud Bros. and Seabrook, sewer and water lines; King Heath, three bridges; Bodenheimer Construction Co., three bridges. All engineering surveys, plans and specifications, and inspection were prepared and performed by the Roy D. Keyes Engineering Organization, of San Diego.

Two Hundred and Eighty Million Gas Tax for 1928.—According to a bulletin of the American Research Foundation, gasoline taxes in 1928 will total $280,000,000. This figure is based on collections for the first six months of 1928, which amounted to $140,635,398. In 1919 the taxes reached only $1,022,514. Nine years ago only four states levied a tax on gasoline.

Building Bridge No. 1. The Overall Length Is 81 Ft. with 68 Ft. Clear Span. The Paneling Is Bush Hammered

The Economics of Asphalt Pavement Construction*

Equipment and Its Construction The Factor Discussed

By T. WARREN ALLEN
Chief, Division of Management, Bureau of Public Roads

THE large amount of money spent annually on highway improvement and the rather indifferent attention given to ways of management which would increase the production with the money available, a few years ago prompted the Bureau of Public Roads to make a study of the question, particularly from the standpoint of construction methods. It is not contended that highway improvement stands alone as an example of inefficiency. There is always room for better management in all lines of endeavor. The yearnings of highway contractors for more favorable unit prices is paralleled by the endeavor of some utility companies to secure greater rates. In my opinion, however, relief in either case should first be sought not in greater unit prices or rates, but in better management under prevailing conditions.

The Division of Management of the Bureau of Public Roads has for some time been studying methods and costs of Portland cement bound pavement construction and has just lately begun a similar study of bituminous bound pavement construction. We find there is fully as great opportunity to improve methods and reduce costs in bituminous construction as in Portland cement concrete construction.

Bituminous pavement construction is a business. It requires a sufficient amount of capital, a proper plant, an efficient organization and managerial ability of high order if the business is to be successful. The studies we have so far made may be said to have done little more than to point the way for future investigation. But the leads we have developed are very promising ones and indicate a very great need for such an investigation as we now have under way.

A Manufacturing Process.—The construction of a bituminous pavement is essentially a manufacturing process, consisting largely of specified or approved methods and equipment by means of which certain materials are assembled, treated, proportioned, combined, transported, placed, spread, consolidated and finished into a smooth and enduring road surface conforming in all respects to the requirements of approved plans and specifications. The steps involved consist essentially of a progressive series of consecutive operations, all of which must be completed in their established order within certain rather definite time limits or the contractor will find not only that his rate of production is low but that the losses resulting from that rate may be increased by a loss of the cost of the processing which has been given the materials and if the processing has passed a certain stage this loss may also include the materials as well. In constructing bituminous pavement the contractor cannot heat his materials today and use them tomorrow; neither can he mix more batches today than he can haul today, nor can he haul more batches than he can spread and consolidate while the materials are still hot. In fact, once the materials have been fairly started through the plant there can be no stopping until these materials are in final place in the road. Managerial ability and skill in operation thus become one of the deciding factors in attaining and maintaining any reasonable degree of efficiency in this line of work.

Plant Equipment.—The most obvious thing about a bituminous paving job is the mixing plant with accessories. So far we have concerned ourselves only with plants for preparing a hot mix. These consist of equipment for getting the aggregate to the plant site, the drying and heating equipment, the screening and proportioning equipment, and the mixer. There have been almost as many varieties and arrangements of these articles of equipment on the projects we have studied as there have been jobs. That in itself is an indication of chaos, and chaos always spells waste.

In bituminous pavement construction, as in other lines of highway work, the fitness of the equipment and the skill with which it is operated, not as individual units but as a coordinated whole, usually indicates long before the job is completed whether the contractor will be able to secure a profit. Of course, anyone with plenty of cash or credit can secure a most imposing array of equipment. But to choose or select such equipment as will form a sturdy, reliable plant of properly balanced capacity, one suited to the work it is to perform and possible of efficient and economical operation requires more than either plenty of cash or credit. It requires knowledge and experience gained only through a mastery of every detail of the work, both theoretical and practical. But even a perfect plant will not produce good results without the application of real skill and ability in its operation.

Management Important.—Perhaps the chief reason why managerial ability plays such an important part in bituminous pavement construction is that the construction of bituminous and similar types of pavements generally involves more different steps or operations than any other common type of construction. To secure and maintain even a reasonable degree of efficiency in this work, all the various operations must be synchronized and the rate of each gauged and balanced to that of the key producer or controlling operation. It may be accepted as an axiom that you can lay no more square yards of pavement per hour than you can pass through the slowest of your operating steps or processes. Greater individual unit capacity for any given piece of equipment is of no value to you except where it serves to compensate for known or reasonably expected variations or fluctuations. Thus, where a 60-second cycle is required, a mixer which can handle a 3,000-lb. batch per minute is no better from a production standpoint than a 1,500-lb. mixer if your drier can only handle materials at the rate of 1,500 lb. per minute. But on the other hand, to install a drier which has no reserve capacity is almost sure to prove a decidedly poor investment. Your plant should be capable of efficient operation whether the temperature is 50 deg. or 100, and whether the original materials are dry or wet. But the rate at which you can put the materials through the drier naturally varies somewhat with their initial temperature and especially with the amount of moisture they contain. Thus, a sand containing 5 per cent of moisture will require approximately twice as much heat to bring it to a temperature of 400 deg. as when it is dry. A drier capacity considerably larger than ordinarily indicated is therefore a necessity if you expect to maintain your plant at capacity production regardless of air temperatures and the moisture content of the sand.

We are now engaged in a study of the general arrangement of plant machines and operations, and in particular, of the drying. The cost of heating is considerable and it does not seem economy after the aggregate has been well heated to subject it immediately to a cooling operation by separating it in

the little pans of the elevator, carrying it up through the cooler air for some distance and then running it through a revolving screen where the air freely circulates. Furthermore, after all this trouble and expense, it is usually found that the aggregates are not of the proper proportions. One bin fills faster than it should and generally in such cases the aggregate has to be emptied from it and returned to the unheated stock pile.

Relative Output.—Another factor which requires careful consideration in balancing the capacity of the equipment is the relative amount of base or binder required, the specifications therefor and the conditions under which it can be laid. The customary specifications seem to require that top be mixed 15 seconds longer than base or binder. Thus, when change is made from top to base the drier will be called on to handle about 25 per cent more material in order to work the mixer at full capacity. A similar increase will also be required in the hauling equipment. Since the construction of top and base or binder must usually be carried on with more or less frequent changes from one to the other, the contractor is seldom able to utilize fully the inherent advantage of the shorter mixing time permitted for the base or binder course. This is a rather serious factor and raises the question as to the necessity and value of requiring that the top be mixed a third or more longer than the base. Furthermore, the time lost in changing from base to top is often considerable. In isolated cases, it has been as much as two hours. The difference in thickness of base and top courses and in consequence the difference in amounts for these courses delivered on the road requires a variation in speed of laying which indicates, if a finishing machine is used, that these machines should be provided with more than one speed ratio. If a change in design is possible, permitting this type to be built in one course, these difficulties may be overcome. Studies we have so far made indicate the possibility of properly consolidating a single course at least four inches in thickness. Samples taken from both the top and the bottom of a two-inch course have in practically every instance shown a greater density in the bottom than in the top.

Mixing.—Even where there is a definite mixing time set in the specifications, which is not always done, the mixing performance on the job is far from uniform. On one observed job the mixing time for base varied from 10 seconds to 50 seconds, with 55 per cent of the batches at from 10 to 15 seconds. The top on this job was mixed for from 15 to 90 seconds, with 20 per cent of the batches mixed for from 25 to 30 seconds. The top on this job was in the case of 7 per cent of the batches mixed from 15 to 20 seconds, 15 per cent was mixed from 20 to 25 seconds, 21 per cent from 25 to 30 seconds, 15 per cent from 30 to 35 seconds, 12 per cent from 35 to 40 seconds, 10 per cent from 40 to 45 seconds, and 5 per cent from 45 to 55 seconds. On other jobs studied there were fully as great variations. We are endeavoring to ascertain what length of mixing or how much mixing for mixers of different character will produce a uniform mixture. In this connection we are finding out that with some styles of mixer the mixing does not proceed at the same rate in all parts of the mixing box. It is readily understood that with widely varying mixing times there will be produced mixtures of varying stability which are quite likely to develop roughness in pavements made of them. There seems no adequate reason to me why it should not be possible as in Portland cement concrete to develop definite times for mixing and use timing devices similar to those used to govern the time of mixing Portland cement concrete.

Plant Coordination.—The full effect which the lack of proper plant coordination and the proper synchronization of its operation has on the rate of production and consequently on unit costs, does not seem to be fully realized by most contractors. Nevertheless, it is a fact that the daily or hourly operating cost of any of our average asphalt road building outfits is very nearly the same whether it is operating at its maximum rate of production or at almost any conceivable point below its maximum. Consequently, if an outfit is operating at one-half of its possible rate, the operating and fixed overhead cost per unit of production is certain to be about twice as high as it should be. This is no small item. The hourly operating cost which includes all labor, supplies, overhead and rental value of the equipment, is seldom less than $30 per hour, and for a large plant may be more than three times this figure. If your outfit is costing you, say, $50 an hour and you are placing only 40 tons an hour, your operating cost is at the rate of $1.25 per ton. But if you can increase your rate of production to 50 tons an hour or 25 per cent, you have at once reduced your operating to about $1.00 a ton. In other words, you have added to the right side of your ledger the neat item of $12.50 per hour or about $125 per ten-hour day of actual operation. This is well within the limit of attainment by many outfits if they will give the necessary attention to management. It is no uncommon thing to find outfits which are operating at least a considerable portion of the time at not to exceed 50 per cent of their possible and readily attainable efficiency.

Lack of Standardization.—During the past year we have studied the various operations on a considerable number of going asphalt jobs. The first and most apparent characteristic noted on these jobs was the lack of standardization, both as to equipment and methods of operation. The plants regularly used in bituminous road construction work range in sizes from as small as those capable of handling no more than a 700-lb. batch to those handling a 4,000-lb. batch. This is a tremendous range as compared with concrete paving work, where the 21-E and 27-E mixers are now used almost exclusively. Methods and equipment for handling and heating the materials are, if possible, even more varied. Only in the hauling equipment do we find any considerable uniformity. Here either heavy or medium weight trucks seem to be used by the majority of the plants. The heavier trucks in addition to their large carrying capacity, have a further advantage in that they can be used in connection with large spreader boxes and thus eliminate a great deal of hand labor in shoveling. Light trucks do not have sufficient power to pull the heavy spreader boxes. The use of spreader boxes is not general. It is a labor-saving device worthy of practically universal adoption. They have not been brought to the state of perfection desirable, but in addition to greater economy they aid in securing greater uniformity in the pavement stability, partially because they obviate the necessity of more than two or three men working and walking about in the paving mixture ahead of the finishing machine and minimize the effect of such walking, which is to effect greater consolidation in the parts walked on.

Finishing Machines.—For some years the question of whether or not the finishing machines used in concrete road construction could also be adapted to

Table I—Effect of Repeated Rolling on Density of Sand Asphalt Surfacing F. A. P. 176, Plymouth County, Mass.

Sand Asphalt with a density of 1.76 when spread and raked on road before rolling Nine-Ton Tandem Roller

Number of times roller passed	1	2	3	4	5	6	7	9	10 or final
Average density after rolling	1.90	1.92	1.95	1.97	1.98	1.96	1.99	2.02	1.982
Number of samples from each rolling	16	13	10	9	1	4	3	2	10
Maximum variation between individual samples	0.08	0.13	0.10	0.10	.....	0.06	0.13	0.04	0.11

Table II—Effect of Repeated Rolling on Density of Sand Asphalt Surfacing F. A. P. 176, Plymouth County, Mass.

Sand Asphalt with a density of 1.76 when spread and raked on road before rolling Six-Ton Tandem Roller

Number of times roller passed	1	2	3	4	5	6	7	9	10 or final
Average density after rolling	1.88	1.92	1.93	1.95	1.95	1.98	1.94	2.02	1.995
Number of samples from each rolling	20	16	10	8	3	3	1	1	8
Maximum variation between individual samples	0.12	1.15	1.09	1.12	1.01	0.06	.....	.....	0.14

asphaltic construction has been discussed more or less as an academic proposition. About a year ago, these more or less academic ideas were put to a test and it was found that with a few relatively minor changes the ordinary concrete finishing machine could be used on asphalt work very successfully. We have studied a number of jobs on which this type of finishing has been used and in almost every case, with gratifying results both as to the smoothness of the surface and the cost involved. The only exceptions have been on narrow work or on small or slow jobs where the amount of material placed was insufficient to warrant the added investment cost.

The use of the finishing machine has been almost equally successful on base as on top, on Topeka or bituminous concrete as on sheet asphalt. The forms must, of course, be set a little more carefully, but this need not entail any appreciable expense. Perhaps the best solution would be to adopt a standard steel form as in concrete road construction. Both well developed equipment and trained labor would then be readily obtainable for this work, as it could be drawn indiscriminately from either field. On work 20 ft. or wider the speed of the regular concrete finishing machines is sufficient to care readily for a production of 60 or 70 tons per hour of two-inch construction. On two-lane construction where the width is frequently only 9 or 10 ft. per lane, the traveling speed of the finisher should be increased by the substitution of a better gear ratio. In cold weather a blow torch or other means is required to heat the screed before beginning work. After the screed is once hot, however, the material seems to supply sufficient heat to prevent sticking or picking up providing the work is at all continuous.

A Simple Method.—The operation of the finishing machine on bituminous work is practically as simple as on concrete work. The spreading, whether by hand or by spreader boxes should be high enough to provide a light ridge or roll of material in front of the strike-off at all times. It seems to be advisable to have the screed slightly higher at the toe than at the heel. A suitable and rapid means of adjusting the height of the screed should also be provided. In all cases which we have studied so far the use of the finishing machine has been able to reduce the number of laborers. With more experience it is believed that where suitable spreader boxes are used in connection with the finishing machine, it will be readily possible to reduce the present shovel and raking crew of 18 or 20 men to about 5 or 6 men whose chief duty will be to keep a proper amount of material in front of the finishing machine and to tend the spreader boxes for the trucks. I am of the opinion that the perfection of spreader boxes will render all raking unnecessary.

The greatest advantage to be expected from the use of the finishing machine, however, is not perhaps so much in reduced labor cost as in the production of a more uniform and smoother road surface and the ability to handle a larger tonnage on the road. With the old method of hand spreading and raking, operation frequently placed a definite limit on the amount of material which could be placed per hour. This was especially true in hot weather, which is otherwise the best time to lay asphalt. With the use of suitable spreader boxes and a finishing machine properly adapted to this work, the only limit on the rate at which you can place the material on the road will probably be the rate at which your rollers can do the necessary consolidation.

Amount of Rolling.—This, then, raises the question as to the amount of rolling required, the size or weight of roller best adapted to this work, and last but not least, the question of the rate and manner in which the consolidation takes place. The work we have been able to do so far along these lines is as yet too limited in extent to serve as a basis for definite conclusions, but it does point quite definitely toward certain probable conclusions and seems to open up some still unexplored fields. Samples have been taken from the roadway after various passes of the roller and these tested for both density and stability. Tables I and II are fairly typical of the rate at which the density increases with repeated rollings. The stability determinations follow roughly a similar curve. Here it will be noted that beginning with a sand asphalt material which had a density of about 1.76 as it was spread and raked on the road ready for the roller, the density increased very rapidly and after four or five passes the increase for each additional rolling became very slight, so slight in fact that it at once raises the question as to the point at which further rolling ceases to add sufficiently to the wearing and riding quality of the road surface to be worth while. It is also interesting to note that for the studies so far made the rate of consolidation is not in proportion to the weight of the rollers. The density secured from the use of the 6-ton roller was practically the same as that from the 9-ton roller. This, therefore, raises the further question as to the best weight of rollers for this kind of work and also at which point the asphaltic surface reaches sufficient stability to prevent displacement under traffic—in other words, the point at which the pavement can be thrown open to traffic and final or any further necessary consolidation left to traffic.

Rate of Cooling.—Some studies have also been made of the rate at which the asphaltic material cools on the road. Eventually these studies should throw some light on the temperature at which the materials should arrive on the road and the length of time it is worth while to continue the rolling. So far it seems that there is a rather wide range throughout which the rate of consolidation is largely independent of the temperature; also, that a temperature, varying no doubt with the penetration of the asphalt used, is soon reached, after which further rolling produces but little apparent effect.

Now these things, as to the rate of consolidation or increase in density and stability with repeated rollings, the point at which this rate breaks and approaches a horizontal line, the effect of rollers of different weights on the rate of consolidation, and the final density which can be attained from the use of each, the effect of the temperature of the materials on the rate of consolidation and the rate at which the materials cool on the road, are all questions which probably have a rather intimate connection with the degree to which the materials should be heated at the plant and the kind and amount of rolling which they should be given on the road and thus have a very vital connection

Table III—Time Losses on Asphalt Construction Work F. A. P. 451-A, Emanuel County, Ga.

Major Delays to Production
(Includes only definite stops or delays each of 15 min. or more in duration)

Cause	Hrs. lost	Per cent of total available time
Weather (rain and wet subgrade)	252.0	31.8
Moving plant to second set-up	71.0	9.0
Plant breakdowns and mechanical trouble	32.8	4.1
Changing from top to base, etc.	10.5	1.3
Miscellaneous causes	29.0	3.7
Total time losses	395.3	49.9
Total time available	793.0	100.0

Minor Time Losses—Each of less than 15 min. duration

Cause	Per cent of total working time
Waiting for trucks	4.5
Mixer, operator	2.1
Mixer, mechanical trouble	0.8
Elevators, mechanical trouble	1.3
Drier, mechanical trouble	1.2
Drier, waiting for hot materials	8.4
Asphalt heater	0.9
Asphalt pump	0.2
Power plant	1.7
Batcher, mechanical trouble	2.0
Miscellaneous	2.3
Total	25.4

Table IV—Time Losses on Bituminous Concrete Construction Work F. A. P. 121-B, Monrovia, Cal.

Major Delays to Production
(Includes only stops each of 15 minutes or more in duration)

Cause	Hrs. lost	Per cent of total available time
Truck shortage	1.5	1.1
Mixed trouble, mechanical	0.5	0.4
Finisher, mechanical trouble	0.5	0.4
Screen clogged	0.5	0.3
Total time losses	3.0	2.2
Total time available	136.0	100.0

Minor Time Losses—Each of less than 15 minutes duration

Cause	Per cent of total working time
Waiting on trucks	11.8
Drier, waiting for hot materials	9.2
Asphalt filling and emptying can	4.6
Mixer, mechanical trouble	1.5
Mixer, operator	1.0
Screens	0.2
Miscellaneous	0.5
Total	28.8

with both what your unit costs shall be and also the traffic value of the finished road surface. It is evident that the variables involved are too many to be solved except by studies and tests covering a very wide range of actual field conditions. I am therefore merely calling to your attention some of these things which we have noted in our studies during the past year, not as conclusions or established facts, but as indications which it seems are decidedly worth much further study and investigation, not by this bureau alone but by all of you, so that we may be able to establish from our joint experience a much greater number of such facts as will help to increase production, decrease unit costs and yet produce as good or better roads.

Greater Consolidation.—It appears possible to consolidate asphalt paving mixtures considerably more than can be done by the present methods of rolling. We have put paving mixtures just as they came from mixing under pressure and we have tamped such mixtures before putting them under pressure and have secured materially greater densities by first tamping. The question as to whether through such additional consolidation materially greater road service may be obtained has not yet been answered. If it can be shown, it may be that other means than rolling, or at least than the present methods of rolling, will be developed to secure such consolidation.

During the past summer we have kept rather complete records on a number of jobs of the various causes which interfere with production. Tables III and IV are summaries of the time losses on two typical jobs. The first job is fairly typical of the smaller plant and had a mixer capable of handling only a 750-lb. batch. The hauling equipment was good and the plant and other equipment could be classed as fair. The record covers a period of 793 available working hours, of which the job was actually working only 398 hours. A total of 395 hours, or practically one-half of this available time was thus spent in enforced idleness. The largest loss was, of course, due to the weather, which in this case included a rather unusually rainy period. Two hundred and fifty-two hours or 31.8 per cent of the available time was lost due to rain, wet subgrade and kindred causes. During the greater part of this time the payroll expenses of a crew of 68 men were limited to four or five straight-time men including the superintendent, time clerk, one foreman and a night watchman. Moving the plant to a new siding consumed 71 hours, while plant breakdowns, mechanical troubles and changing from one mix to the other consumed an additional 43 hours and a variety of miscellaneous causes consumed the other 29 hours. Practically one-half of the best portion of the contractor's working season was thus irretrievably lost so far as possible profitable operation was concerned.

Minor Delays.—But this was not the end of the contractor's time losses. More than one-fourth of the time or 25.4 per cent of the total time he was actually on the job with his full crew was lost in minor interruptions and delays. Thus, a total of 10.5 per cent of the time he was out on the job was lost in waiting for hot materials; 6 per cent was lost because of minor mechanical troubles, chiefly at the plant; 4.5 per cent was lost because of inadequate truck supply; the mixer operator added 2.1 per cent to the contractor's already sufficient burden, while 2.3 per cent of the time was due to various miscellaneous causes. The operating cost of this job was approximately $350 per day. Consequently, a loss of an average of 25.4 per cent of the working time represented a shrinkage in the contractor's possible profits of over $80 per day. Not all of these minor time losses can be eliminated, but we have yet to find a job with large time losses of this nature, or in other words, operating at a low rate of efficiency, on which it has not been possible to materially reduce the time losses, increases the rate of production, and decrease the unit costs.

Another job which can be considered as typical of large plants, during the best part of the construction season, showed a total loss of only three hours in actual stops of any considerable duration. This particular study only covered a period of three weeks during the dry weather or the month of August, consequently no time was lost due to rain or wet subgrade. The total available time was 136 hours, of which the crew was on the job all the time and of which the plant was shut down only a total of three hours in stops longer than 15 minutes in duration. Thus, on this job during the time of the study, less than 2¼ per cent of the total available working time was lost in stops of appreciable duration. A really available record!

A Good Example.—But in the matter of minor delays this job was not so fortunate. The record shows that an average of 28.8 per cent of the time was lost in minor delays varying from a few seconds to 5 or 10 minutes each. Even during the best week these delays absorbed 25 per cent of the working time. The largest and most persistent cause of this loss, amounting to 11.8 per cent, was the lack of really sufficient trucks and the fact that those on the job were not operated on any regular schedule but allowed to bunch up from time to time. This plant had no hopper or "gob box" for storing the mixed batches, but each batch was dumped directly into a waiting truck. The batch weighed 4,000 lb. and each truck carried three batches. Consequently, whenever a truck was not immediately on hand to drive under, the mixer was forced to wait until one arrived. A "gob box" which would have held three batches, or a full load, would not only have decreased the loading time of the trucks but would also have absorbed a reasonable factor of variation in the flow of the truck supply. The next large factor in causing these minor interruptions to steady production was drier delay which absorbed 9.2 per cent of the working time. Nearly all of this delay was due to poor regulation of the correct proportion of the various sizes as fed into the cold elevator. This frequently caused either a shortage or overflow of hot materials in some one of the four hot bins. In other words, the usual methods of feeding the cold elevator with materials for bituminous concrete are difficult to work so that the supply of each of the several sizes going into the drier will always be in the right proportions. Sooner or later we will no doubt develop some thoroughly practical method of properly proportioning the materials as or before they enter the drier. This should prevent a considerable loss in heated material which must now be run out of the overfull bins, and it should also cut down the heat losses in the present long passage of the materials between the drier and the mixer. Poor asphalt handling on this job also accounted for a total of 4.6 per cent of the lost time. Where a large batch is used the question of handling the rather large volume of asphaltic cement must be worked out very carefully, otherwise time is likely to be lost regularly with each batch. Even comparatively small individual time losses of this kind often accumulate to a rather surprising total during the course of a day. On this job the mixer gave a little trouble and the operator did not seem to be aware of the value of seconds, so that an average of 2.5 per cent of the available time was wasted here. Miscellaneous time losses from various causes consumed an average of 0.7 per cent of the time, completing the total of 28.8 per cent time loss.

Effect on Unit Cost.—The effect of these time losses on the unit cost of this job may be worth an examination. The hourly operating cost including labor, supplies, rental value of equipment and overhead exceeded $100 an hour with a production of about 75 tons an hour, or approximately $1.35 per ton. If all the time losses could have been eliminated the contractor could have placed 104 tons an hour with probably only the added hourly cost of two or at most three extra trucks to haul the additional tonnage to the road. The unit operating cost could then have been cut to about $1.05 per ton, a reduction of 30 cents a ton. In other words, the total elimination of just these minor delays, each of so short duration as to generally escape notice except under the most careful observation, would have been worth over $200 per day to the right side of the contractor's ledger. Even the reduction of his time losses

by one-tenth would have amounted to some $20 per day, surely a worth-while accomplishment.

From the standpoint of production and unit costs the equipment and the methods of its operation thus, to the contractor, spell the difference between profit and loss. What particular types or kinds of equipment will prove the most efficient and economical we are not yet prepared to say. But we do know that to secure a degree of efficiency which will result in low unit costs, each piece or part of the equipment must be such as will fit into and form a part of a composite unit which taken as a whole will be sturdy, dependable, of fairly well balanced capacity and capable of economical operation. It seems probable that a considerable latitude and ingenuity is possible in the selection of the individual units and fitting them into an efficient and effective plant. Much the same thing applies to methods of operation. If they will contribute toward more efficient production without any detriment to the desired quality they are good and should be adopted. But if they will tend to decrease the rate of production, increase unit costs or decrease quality, they are to be condemned.

Serious Thought Needed.—In closing I cannot refrain from saying that I think we should give more serious thought to the economic aspects of highway improvement. The funds available are limited and the work to be done is unlimited. We must therefore seek the greatest possible accomplishment with the funds available. We must in every phase of the work enlist the keenest minds. It is not a one man's job, or the job of one set of men, or of one industry. We are living in an age of stupendous progress, of stupendous prosperity. The enormous traffic that is already upon our highways will be doubled and trebled and we, upon whose shoulders the burden of preventing the strangulation of progress, through limited means of transportation, must use every means at our disposal if we are to successfully cope with the situation.

Acknowledgment.—From a paper read before the Seventh Annual Asphalt Paving Conference, New Orleans, La., Dec. 3-7, 1928.

Highway Nail Picker Adds to the Variety of Its Diet.—The New Mexico State Highway Nail Picker on a recent courtesy trip through one of the towns of the state made a surprising number of "pickups" on what was a supposedly clean pavement. The machine in two hours and a half picked up four large boxfulls of metal objects. The stuff gathered included tobacco cans, coco cola bottle tops, hair pins, valve caps, nails, needles, tacks, keys, odd shaped bits of metal and scrap.

Progress of Highway Research

Expenditures in the United States for highway research last year probably totaled nearly $1,000,000, declared Dr. A. F. Woods, director of Scientific Research of the United States Department of Agriculture, in an address given before the Highway Research Board of the Division of Industrial Research, National Research Council, in Washington, Dec. 13. The outlay for the year for this purpose by the Bureau of Public Roads alone, he said, was $400,000. Nearly an equal sum was required to support the investigations of the state highway departments and substantial additional outlays were made by the various agricultural experiment stations and colleges. As evidence that money spent for highway research in the past has been well spent, he said it was sufficient to point to the excellence and efficiency of modern highways.

Doctor Woods described the progress of highway research from the early period "when the requirements of horse-drawn traffic were predominant, to the present era of heavy and incessant motor vehicle traffic. Early experiments were made with burnt clay as a surfacing material. Sand clay mixtures were tried. In 1893, or thereabouts, the farmer was the largest and indeed almost the only rural road user, and the commonest vehicles were the farmer's buggy and wagon. The gasoline motor and rubber-tire were still beyond the horizon. Under such conditions, methods of road making adapted to traffic light in volume and in weight and limited in range sufficed. For roads for the heaviest traffic the bureau then advocated the macadam surface, not a mere scattering of rocks but a rolled road of two courses, with much emphasis on crown and drainage.

"In the last years of the nineteenth century the Bureau of Public Roads, in cooperation with the University of Tennessee, devised a recording instrument called a tractograph for the measurement of tractive power. Records made with this tractograph led to experiments that promised to have great importance. The bureau entered upon an investigation of the possibilities of steel roads. In 1898 it laid, on the outskirts of Cleveland, Ohio, a 500-ft. channel-bar trackway set in a macadam surface. This road, as the bureau reported, was laid in a street carrying a heavy volume of traffic and demonstrated the great value of steel in road construction. We might today be travelling on steel tracks had not another group of experimenters hit upon an idea that made radical changes in the character of vehicles and their tires. These experimenters, of course, were the pioneers in motor traction.

"Intensive scientific investigation was started by the bureau about 1905. Each year thereafter it constructed one and sometimes more experimental roads. In these roads experiments were made with various bituminous materials applied as surface treatments. A little later a mixing method—the beginning of bituminous concrete — was tried. Rapid strides were made in the development and standardization of tests, and the work resulted in a notable series of circulars entitled 'Dust Preventives and Road Binders.' In 1911 the bureau began constructing its best-known experimental road. This is in Washington, D. C., on Connecticut Ave., beyond Chevy Chase Circle. Construction was started with bituminous macadam sections; and continued in 1912 and 1913 with the building of bituminous concrete, concrete and brick sections. When this road was built the country had only about one million motor vehicles. Traffic was still predominantly horse-drawn. Yet the road has lived to serve a constantly increasing traffic of automobiles and motor trucks to the present day.

"For 15 years this stretch of roadway was carefully maintained by the bureau, and a record kept of every expenditure and of all traffic carried. It is believed that no other road anywhere in the world exists for which there is such a parallel record of cost and traffic covering so long a time. The undertaking was followed by what may be termed the modern period of the bureau's experimental work, in the course of which bridge slab tests were begun in 1912, soil pressure tests in 1915, the earlier wear tests in 1919, and the impact experiments in the same year. Analysis of sub-grade soils was begun in 1920 and of traffic surveys in 1922, and many lesser tests and experiments were carried out. This work, in common with research work in general, has been of fundamental importance in the practical solution of the highway problem."

Doctor Woods urged the Highway Research Board to interest itself in the improvement of roads leading directly to farms. He pointed out that only 300,000 miles of the 3,000,000 miles of public rural roads in the United States are included in the main heavily traveled highways. Farmers are interested in these highways, but they are perhaps more interested, he believes, in the local road mileage outside the main system. He said traffic carried by these local roads is not sufficient to support the types of improvement on which the investigations of the Highway Research Board have mainly been centered.

The board could render an exceedingly important service, in his opinion, by devoting some time and attention to the solution of the problem of the local roads. The Bureau of Public Roads, he continued, has had much success in bringing about cooperation among county and municipal authorities concerning highway administration in certain metropolitan areas.

Laying 18 Miles Concrete in One Season

The Equipment, Organization and Method of Handling Work

By A. E. WEBSTER

AN excellent record for the amount of concrete pavement laid with one outfit in one season was made in Wisconsin last year when the Morris Martin Company of Berlin, with one crew, placed about 18 miles of highway. The work totaled 204,000 sq. yd.

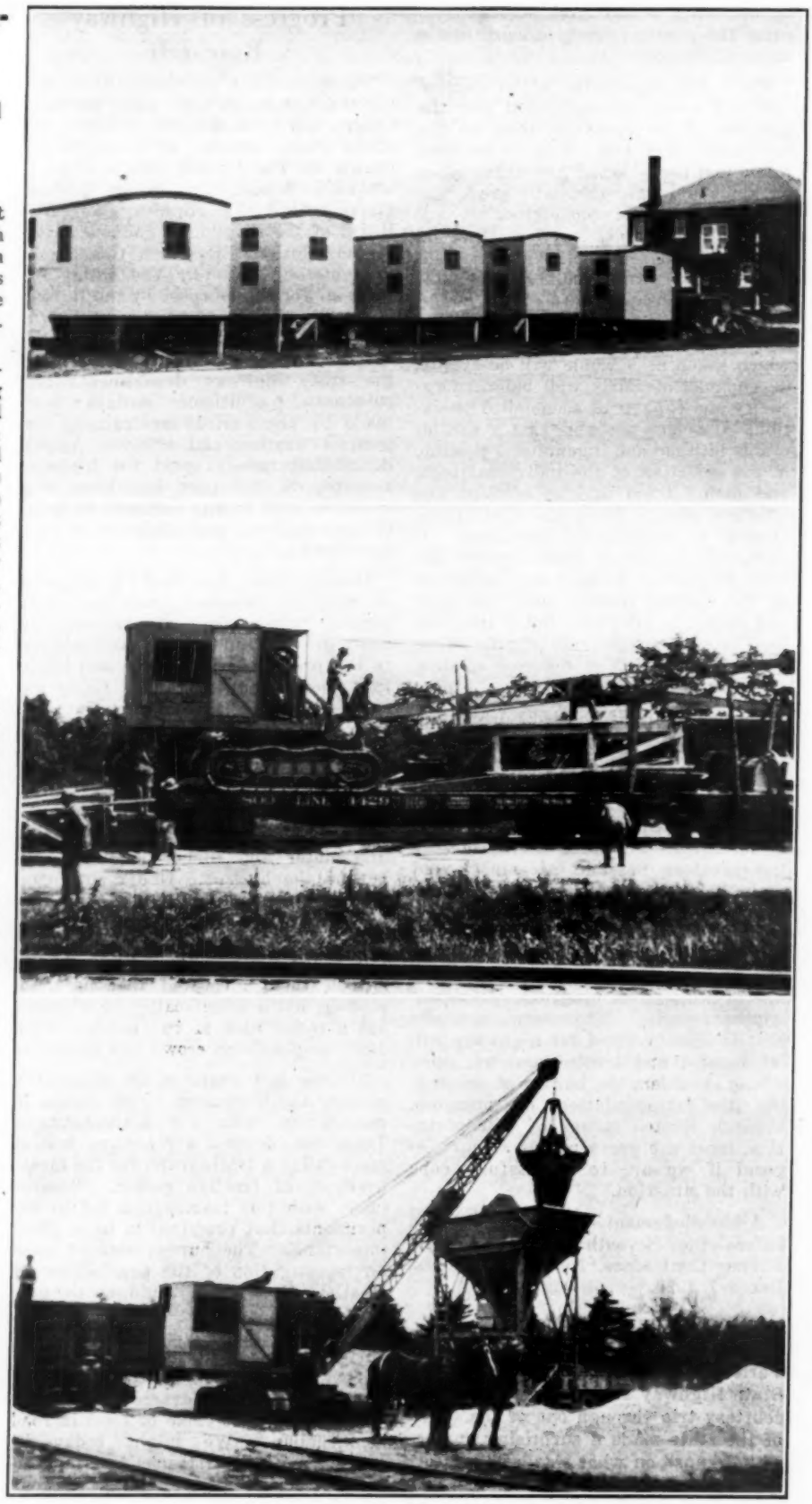
This record becomes even more notable when it is stated that the paving consisted of four different jobs located as widely as 35 miles apart; that 2½ miles of the highway had to be re-located over virgin soil, where foundations were shifty and uncertain, in order to avoid railroad grade crossings; that 2200 ft. of the pavement had to be built through a swamp where heavy clay made progress difficult, and 800 ft. through woods where a gravel road requiring 2600 sq. yd. of material had to be constructed to haul materials over before the highway could be built.

Lay a Mile a Week.—The work began on May 7 and ended on Nov. 3. During the 113 working days an average of 83 lin. ft., or 184 sq. yd., of concrete was placed each hour. The average time required to construct a mile of highway was 63.75 hours. The most rapid progress was made on a 2.4-mile stretch between Vesper and Wisconsin Rapids, which was built in 138 hours, an average time per mile of 57.5 hours, or slightly less than one working week. The work did not include curbs and gutters, culverts or concrete riprap which were sublet. All paving was 20 ft. wide except the curves where 4 ft. additional were placed, and a certain 2.4-mile stretch which was 16 ft. wide but which was so heavily reinforced that it required even more time to lay than the standard 20-ft. width.

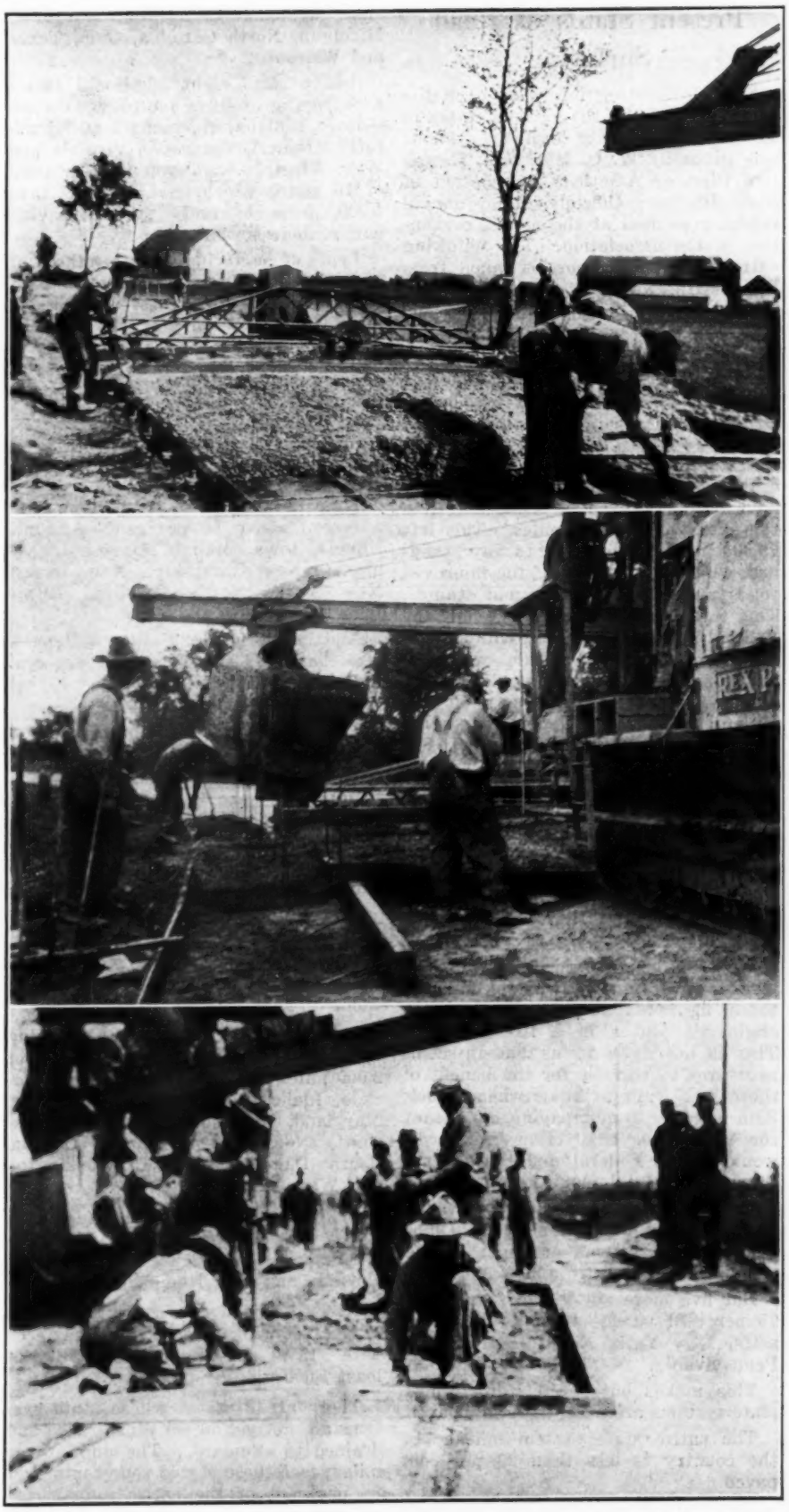
The four jobs included a 7.5 mile section between Junction City and Stevens Point on U. S. Highway No. 10; 5.5 miles also on U. S. Highway No. 10 between Amherst and Waupaca; 2.4 miles on State Highway No. 54 between Plover and Wisconsin Rapids, and the same distance between Vesper and Wisconsin Rapids.

Equipment and Organization.—The equipment used by the Morris Martin Company in securing speed included a standard 6-bag 1928 paver and a 51-ton combination hopper, stone batcher and sand-weighing batcher. Seven 3-batch trucks and two 2-batch trucks were used.

Trucks were loaded with correctly proportioned sand and gravel at the batchers and then were driven to the cement car where the proper amount of bulk cement measured by weight,



Top View: Portable Bunk Houses and Mess-Car Arranged Conveniently to the job. Middle View: For Long Hauls Between Jobs Two Flat Cars Carried the Equipment; on Short Distances It Went Over Highway. Bottom View: Crane Charging Bins; Team in Foreground Spots Cars to Any Desired Point and Keeps Stock Pile and Tracks Cleaned Up. Note that Contractor Did Not Build Up a Pile of Material Parallel to the Track Between the Track and Bin on Which to Operate His Crane. This is a Small But Economically Important Point



Top View: Machine Finishing, Rolling and Belting the Pavement. Middle View: For the Extra 4-ft. Width at Curves, the Regular Steel Forms Were Placed on the Outside; As the Finishing Machine Was Only 20 ft. Wide, a Specially Designed Wood Form Was Used on the Inside; This Was Immediately Pulled Out After Placing the Concrete, Thus Conforming to State Requirements for a 100 Per Cent Monolithic Pavement. Bottom View: Finishing High-Early-Strength Concrete Railroad Crossing That Was Used 24 Hours After Placing.

was added. Three 2-wheel carts holding a barrel and a half each, were employed in handling the cement, one cartful being used for each batch. After receiving their load of proportioned sand, stone and cement, the trucks were driven to the job. Water was conveyed to the mixer from nearby streams by pumps of a type generally used and measured by an automatic device. The contractor used a 1:2:4 mix and the mixing time was 1 minute after all materials were in the drum. Steel forms were employed for the 20-ft. roadway, and a specially devised wood form, as seen in the picture, which could be easily removed, for the 4 feet of additional pavement placed at curves. The pavement was machine finished, rolled and belted according to state specifications, as shown in the accompanying illustration. Quarter-inch expansion joints were placed 48 feet apart.

Organization totaled about 50 men. One man was stationed at the crane to charge the bins with sand and stone from the storage piles or railroad car; one was at the bins and one man in car; five handled the cement; one driver was allotted to each truck and the usual crews were used for mixing, paving and finishing.

High-Early-Strength Concrete. — A feature of the construction was the use of high-early-strength concrete in placing a railroad crossing near Wisconsin Rapids. This concrete, made with the usual materials and labor according to methods outlined in booklets issued by the Universal Portland Cement Co., reached a strength that permitted removal of forms and use of the crossing in 24 hours. The picture shows men finishing this section. In addition to high early strength, it was permanently stronger and more durable than concrete as ordinarily mixed and placed. Instead of the usual 1:2:4 mix, a 1:1:2 mix was employed and the amount of water was cut down to the minimum consistent with securing workability in the concrete. Ability to use this section without delay helped to speed up the whole job.

How Speed Was Secured.—Four factors aided in making it possible to establish this new record in highway construction. The first was a smoothly functioning organization with little labor turnover and with a nucleus of experienced men who have been with the Martin company many years. More than 80 per cent of the men who began work in the spring were on the job when the season ended. Adam Markowfski, vice president and superintendent of the company, has been with it over 12 years and knows all the ins and outs of the game. Mr. Martin, president, has had 18 years experience as a contractor and is familiar with all angles of paving work. N. M. Isabella, secretary and engineer of the company, was connected with the Wisconsin State Highway De-

partment for 13 years. His technical skill, with the contracting experience of the other members of the firm, insures a well-balanced organization.

A second factor in securing speed was good equipment. No time was lost because of ill-conditioned or worn-out units. The bins, paver and seven of the trucks were new. The balance of the machinery was in first-class shape due to the fact that several men, retained the year around, spend their winters in overhauling equipment and putting it in good condition.

Materials Always Available.—A third reason for the rapid construction was the availability of materials. On three jobs materials were shipped in and on one job they were produced locally. In no case was there delay in securing adequate quantities. This enabled labor and equipment to keep busy. A railroad siding with a capacity of 70 cars was near the job. Cars were "spotted" by a team to any desired point as seen in the picture. Some 15 to 20 cars were unloaded each working day. Material was unloaded from the cars by a crane with a 40-ft. boom and a 1¼ yd. bucket and placed either directly in the bins or, if they were full, was placed in the stock piles beside them. This continuous supply assured uninterrupted operations.

A final factor in establishing this new record for construction was the ability of the Martin crew to move rapidly from one job to another. Within two hours after finishing one project they were ready to move to the next one. Portable bunkhouses as shown in the illustration, each with facilities for 12 men, were mounted on chassis. When moving time arrived they were connected with trucks and were soon on their way. Similarly, the dining department, able to feed 50 men, with a permanent chef in charge, was on wheels and could be shifted quickly from one job to the next. On short hauls of a few miles, the batcher and the mixer were taken via the highway to the next job. For long distances they were placed on two flat cars, as seen in the picture, and shipped by rail. By this means the minimum time was consumed between jobs and actual construction was speeded up, enabling the company to break all previous state records for the amount of paving placed in one season with one outfit.

New Mexico's Federal Aid Allotment Increased.—Word has been received by the New Mexico Highway Department from the Federal Bureau of Roads that New Mexico's Federal Aid rate has been raised from 63.43 per cent to 63.75 per cent. This also increases the maximum allotment per mile from $19,029 to $19,125. Although this increase does not amount to much on small contracts on the total of a year's program it will make considerable difference.

Present Status of Road Surfacing

Some interesting information on the progress made by the various states in surfacing their state highway systems was given by W. C. Markham, Executive Director American Association of State Highway Officials, in his annual report presented at the recent convention of the association. The following extract from his report is taken from Badger Highways.

During the past calendar year 19,500 miles of roads on the state highway systems were given some kind of surfacing and a little over 7,000 miles of earth roads prepared for surfacing. In the hearings before the last session of the Congress it was disclosed that the state systems, including the Federal Aid system; namely, 200,000 miles, have been improved, in some stage, to the extent of 130,000 miles. This left 70,000 miles unimproved to any standard, while 28,000 miles of the improved roads were simply graded and drained. This therefore shows that one-half the Federal Aid system is still without any kind of surfacing. While we were surfacing the 19,500 miles last year, about 11,500 of them were on the Federal Aid system; Federal funds being applied to about one-half or 5,800 miles. The remainder of the Federal Aid was applied to grading and draining. At this rate of construction it will be about 8 years before the state systems will be given the "once over," and in the meantime some of the cheaper types will have had such abuse by the traffic that they will be ready for a "twice over."

We often hear it said that a woman's work is never done. It would seem from these figures that a State highway engineer's job is in a like category. This is not news to us but it seems necessary to state it for the benefit of those who want to know when "Uncle Sam is going to quit paying out money for roads," or that other class who would divert Federal and State funds for a purely local requirement.

Only 7 States 50 per Cent Paved.—There are but two states in the Union whose state systems are over 75 per cent paved—Delaware and Maryland.

But five more states are from 50 to 75 per cent paved—Illinois, Massachusetts, New York, North Carolina and Pennsylvania.

This makes but seven states whose state systems are more than half paved.

The entire state system mileage of the country is less than 20 per cent paved.

There are three states, however, each having more than 5,000 miles of paved roads—Illinois, New York and Pennsylvania.

Seven additional states have from 2 to 5,000 miles of rural paving on the state systems—California, Maryland, Michigan, North Carolina, Ohio, Texas and Wisconsin.

Add to this eight additional states with paving of from one to 2,000 miles—Iowa, Indiana, Massachusetts, Minnesota, Missouri, Tennessee, Virginia and West Virginia—and you have a total of 18 states which have not less than 1,000 miles of state system paving within their borders.

Types of Surfacing.—Listing the type of road surfacing as "gravel or better," we find that there are three state systems which are 100 per cent surfaced in length whether they are in width or not—Delaware, Indiana and Maryland.

Eight more states are surfaced in like manner above 75 per cent—Connecticut, Massachusetts, Michigan, Ohio, Oregon, Pennsylvania, Washington and Wisconsin.

Then 12 more states come along with a record above 50 per cent—Arizona, Illinois, Iowa, Maine, Minnesota, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Rhode Island and South Dakota.

And so we have 23 state systems—less than half—which are 50 per cent surfaced with gravel or some higher type of construction.

The entire state system mileage of the United States is less than 47 per cent gravel or better.

When it comes to mileages of surfacing, with gravel or some superior quality, the record shows eight states each having more than 5,000 miles—Illinois, Michigan, New York, North Carolina, Ohio, Pennsylvania, Texas and Wisconsin.

In fact two of these states—New York and Ohio—exceed 10,000 miles each.

Then 18 more states come trouping by with banners showing in excess of 2,000 miles—Alabama, California, Colorado, Idaho, Indiana, Iowa, Kentucky, Maryland, Minnesota, Mississippi, Missouri, Nebraska, Oklahoma, Oregon, South Dakota, Virginia, Washington and West Virginia.

Bringing up the rear are 5 additional states with a record of over 1,000 miles—Arizona, Connecticut, Maine, Massachusetts and New Hampshire.

And so we have a list of 31 states in line, showing that each has surfaced with gravel or some better quality at least 1,000 miles.

There are 8 states whose state systems are not yet 50 per cent graded and drained to standard. The unimproved mileage of these states represents over 38 per cent of the entire unimproved mileage of all the state systems. But when it is realized that these 8 states compose more than 27 per cent of the entire area of the United States, their problem can be much better appreciated.

A. R. B. A. Convention and Show Again in Cleveland

Additional Facilities Make Possible More Exhibits and Unusual Program

AGAIN it is possible to promise a bigger and better, a greater and more beneficial convention and show when the American Road Builders' Association meets in Cleveland this month. Each year has shown unusual growth, and when this great annual gathering outgrew the available facilities in Chicago, a move was made to Cleveland. Conditions in that city brought about a further phenomenal growth, making possible the great program and the multitude of exhibits that will be encountered when the visitor arrives in that city on January 14.

The Road Show will be held at the Public Auditorium and the Central Armory, opening officially Monday, January 14, at 9 a. m. Owing to the greatly increased facilities, the exposition will be even larger than last year, and information received from exhibitors indicates that there will be a tremendous number of new developments in both equipment and materials. It is reported that there will be over 500 carloads of modern labor - saving equipment and materials on exhibition.

The Convention.—According to information originating from the Association, a very interesting program is in store for those who will attend. Just prior to the convention, on Saturday, January 12, there will be a meeting of the Manufacturers' Division of the American Road Builders' Association, together with their distributors. On Monday, the 14th, the day will be given over to visiting the exhibits at the Public Auditorium and the Central Armory, together with the usual opening day features. The convention proper starts at 8:30 a. m. on Tuesday, January 15. This first day will be known as City Officials' Day, and will begin at the hour named with a breakfast at the Hollenden for committees and directors of the City Officials' Division and the directors of the Association. The first session will be held in the theatre of the Public Auditorium, where all sessions of the day will be held. The following feature will be a luncheon for the officials, followed by two separate sessions, one for the officials and one for the constructors. The annual business meeting of the City Officials' Division will wind up the afternoon session, and in the evening entertainment will be given in the theatre of the Public Auditorium.

Wednesday will be Pan-American Day, with a Pan-American session in the morning, followed by a luncheon, and then a business meeting after the luncheon. An engineers' and a constructors' session will also be held in the afternoon, and the annual banquet will be held in the Grand Ball Room of the Hollenden at 7:30 p. m.

Thursday will be known as County Highway Officials' Day, beginning with a breakfast at the Hollenden Hotel for the Committees and Directors of the County Highway Officials' Division and the Directors of the A. R. B. A. This will be followed by a business meeting of the manufacturers' division and a county highways officials session. The highway officials will then have a luncheon at the Hollenden, and the rest of the afternoon will be devoted to an officials' session and a business meeting.

Friday, the closing day, will be given over to visiting the exposition, to directors' meetings, and to the annual business meeting of the A. R. B. A. A Directors' luncheon will be held on that day. The exposition will close officially at 4:00 p. m. on Friday, January 18.

The Program.—A highly interesting program has been arranged for all sessions. Besides the unusually interesting committee reports that have been prepared, there will be papers by such authorities as Wm. R. Hopkins, City Manager, Cleveland; by Ward P. Christie, engineer, Associated General Contractors of America; by M. A. Coroalles, construction engineer, Department of Public Works, Havana, Cuba; by A. T. Goldbeck, National Crushed Stone Association; by D. H. Sawyer, secretary, Associated General Contractors of America; by F. E. Schnepfe, Highway Engineering Bureau, Washington, D. C.; and others equally well known.

An idea of the nature of the program may be gained from the following summary of the tentative program announced by the association:

Convention Program
CITY OFFICIALS' DAY

Tuesday, January 15

GENERAL SESSION

Tuesday Morning, 10:00 A. M.

Presiding.—Col. R. Keith Compton, President, American Road Builders' Association. Director, Department of Public Works, Richmond, Va.

Invocation.

Address of Welcome by Hon. John D. Marshall, Mayor of Cleveland.

Response and address by Col. R. Keith Compton, President, American Road Builders' Association.

"Trend of City Government."—Wm. R. Hopkins, City Manager, Cleveland, Ohio.

"The Object of the City Officials' Division"—Capt. H. C. Whitehurst, President, City Officials Division, American Road Builders' Association and Assistant to Engineer Commissioner of Washington, D. C.

"A Resume of the Activities of the State Highway Departments During the Past Year"—C. M. Babcock, State Commissioner of Highways of Minnesota, representing American Association of State Highway Officials.

"The Regional Area, Its Traffic and Engineering Problems, the Responsibility of the Engineer"—Prof. J. Gordon McKay, Director, Cleveland Highway Research Bureau.

CITY OFFICIALS' SESSION

Tuesday Afternoon, 2:30 P. M.

Presiding.—Captain H. C. Whitehurst.

Report of Committee on Administration, Organization and Finance. Chairman, H. C. Whitehurst, Assistant to Engineer Commissioner, Washington, D. C.

Discussion:

Report of Committee on Design and Construction. Chairman, Geo. B. Sowers, Deputy Commissioner, Division of Engineering and Construction, Cleveland, Ohio.

Discussion:

Report of Subcommittee on Subgrades, Foundations and Bases for Pavements. Chairman, C. A. Hogentogler, Senior Highway Engineer, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C.

Discussion:

Report of Committee on Maintenance. Chairman, Major C. E. Myers, Director of Transit, Philadelphia, Pa.

Discussion of Concrete Maintenance, W. E. Barkhuff, City Engineer, Seattle, Wash.

Discussion of Brick Maintenance, F. E. Swineford, City Engineer, Akron, Ohio.

Discussion of Asphalt Maintenance, R. H. Simpson, City Engineer, Columbus, Ohio.

Discussion of Rock Asphalt Maintenance, A. Mason Harris, Chief, Bureau of Streets, Richmond, Va.

Report of Committee on Traffic. Chairman, M. O. Eldridge, Assistant Traffic Director, Washington, D. C.

Discussion, A. B. Barber, Manager, Transportation and Communication, Chamber of Commerce of the United States, Washington, D. C.

CONSTRUCTORS' SESSION
Tuesday Afternoon, 2:30 P. M.

Presiding.—S. M. Williams, Manager, Engineering and Construction Division, Associated General Contractors of America, Washington, D. C.

"Trend of Construction Equipment Design."—S. T. Henry, McGraw-Hill Publishing Co., Spruce Pine, N. C.

Report of Committee on A Study of Liens in Public Construction.—Chairman, A. E. Horst, Secretary and Treasurer, Henry W. Horst Co., Rock Island, Ill.

"Prequalification of Bidders on Public Construction Work."—Ward P. Christie, Engineer, Associated General Contractors of America, Washington, D. C.

Open Forum.

PAN AMERICAN DAY
Wednesday, January 16

PAN AMERICAN SESSION
Wednesday Morning, 10:00 A. M.

Presiding.—Octavio Dubois, President, Pan-American Division, American Road Builders' Association; President, National Highway Commission of Mexico, Mexico, D. F., and Thomas H. MacDonald, Chief, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C.

"Plans and Construction of Central Highway, Cuba."—M. A. Coroalles, Construction Engineer, Cuban Department of Public Works, Havana, Cuba.

"Federal Highway Construction in Mexico"—Octavio Dubois, President, National Highway Commission of Mexico, Mexico, D. F.

"Method of Financing the System of Roads in Chile"—Abraham Alcaino, Chief Engineer, Construction Division, Department of Public Roads of Chile, Santiago, Chile.

"Activities of the Pan American Division of the American Road Builders' Association"—Chas. M. Upham, Secretary-Director, American Road Builders' Association.

"Road Activities in Canada"—S. L. Squire, Chairman, Executive Committee, Canadian Good Roads Association, Montreal, P. Q., Canada.

"Success of the Mexican National Highway Congress" — Frederic A. Reimer, Consulting Engineer, East Orange, N. J., and Salvador G. de Quevedo, Chief Engineer, National Highway Commission of Mexico, Mexico, D. F.

ENGINEERS' SESSION
Wednesday Afternoon, 2:30 P. M.

Presiding. — Gibb Gilchrist, State Highway Engineer, Austin, Tex.

Report of Committee on Depreciation of Equipment.—Chairman, W. A. Van Duzer, Assistant Chief Engineer, Pennsylvania Department of Highways, Harrisburg, Pa.

"Practical Applications of Recent Highway Investigations."—A. T. Goldbeck, Director, Bureau of Engineering, National Crushed Stone Association, Washington, D. C.

Report of Committee on Finance.—Chairman, Chas. M. Upham, Secretary-Director, American Road Builders' Association, Washington, D. C.

Report of Committee on Grade Crossings.—Chairman, E. W. James, Chief, Division of Design, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C.

CONSTRUCTORS' SESSION
Wednesday Afternoon, 2:30 P. M.

Presiding.—W. L. Collins, Hornell, N. Y.

"Recent Changes in Pavement Design and Specifications and How They Affect the Contractor."—Speaker to be announced at a later date.

"The Use of High Early Strength Cement in Highway Work"—D. A. Abrams, Director of Research, International Cement Corp., New York, N. Y.

"The Economics of Grading and Paving Operations"— A. Stellhorn, Holmes Construction Co., Wooster, Ohio.

"Do Construction Costs Justify Present Low Bidding?"—D. H. Sawyer, Secretary, Associated General Contractors of America, Washington, D. C.

Open Forum.

County Highway Officials' Day
Thursday, January 17

COUNTY HIGHWAY OFFICIALS' SESSION
Thursday Morning, 10:00 A. M.

Presiding.—Thomas J. Wasser.

Address by Thomas J. Wasser.—President, County Highway Officials' Division, American Road Builders' Association; Supervising Engineer, Board of Chosen Freeholders of Hudson County, Jersey City, N. J.

Report of Committee on Surveys and Planning. — Chairman, Stanley Abel, Supervisor, Fourth District, Kern County, Taft, Calif.

"Procedure for Making an Economic Survey and Plan for County Highway Development."—F. E. Schnepfe, Highway Engineering Bureau, Washington, D. C.

This consists of a preliminary study of conditions in Prince William County, Va., with a view to making an economic survey and plan for a road program over a period of years.

Report of Committee on County Highway Construction.—Chairman, Chas. E. Grubb, County Engineer, Newcastle County, Wilmington, Del.

Report of Committee on Rural County Highway Maintenance.—Chairman, F. B. Wilkes, Superintendent of Roads, Maury County, Columbia, Tenn.

Report of Committee on Urban County Highway Maintenance.—Chairman, Geo. C. Wright, County Superintendent of Highways, Monroe County. Rochester, N. Y.

MANUFACTURERS' SESSION
Thursday Morning, 9:30

Presiding—Lion Gardiner, President, Manufacturers' Division and Vice-President, Lakewood Engineering Co., Cleveland, Ohio.

W. H. Rastall, Chief, Industrial Machinery Division, Department of Commerce, Washington, D. C.

"Coordinating the Activities of the American Road Builders' Association"—Chas. M. Upham, Secretary-Director, American Road Builders' Association.

"Research, Industrial Exploration"—Maurice Holland, Director, Division of Engineering and Industrial Research, National Research Council, and author of "Industrial Explorers."

Business Meeting.

COUNTY HIGHWAY OFFICIALS' SESSION
Thursday Afternoon, 2:30 P. M.

Presiding.—Chas. E. Grubb.

Address by Chas. E. Grubb.—Vice President, County Highway Officials' Division, American Road Builders' Association; County Engineer, Newcastle County, Wilmington, Del.

Report of Committee on County Highway Legislation.—Chairman, H. B. Keasbey, County Engineer, Salem County, Salem, N. J.

Report of Committee on County Administration.—Chairman, R. B. Preston, Engineer, County Commission of Roads and Bridges, Norfolk County, Portsmouth, Va.

Report of Committee on County Construction and Maintenance Equipment.—Chairman, E. L. Gates, Superintendent of Highways, Du Page County, Wheaton, Ill.

Report of Committee on County Highway Finance.—Chairman, John J. McHugh, Deputy Clerk, Board of Chosen Freeholders of Hudson County, Jersey City, N. J.

Exhibitors at the Road Show

Over 400 manufacturers will exhibit their latest developments in equipment and materials. Many of the exhibits will be in operation and there will be several new types of equipment and improvements in materials on display.

A list of all exhibitors who on Dec. 15 have completed their contracts for space is shown below:

A

Adams & Co., J. D.
Alabama Rock Asphalt, Inc.
Alan Wood Iron & Steel Co.
Alloy Cast Steel Co., The.
Allis-Chalmers.
American Bosch Magneto Corp.
American Casting Co.
American City Magazine, The.
American Gas Accumulator Co.
American Hoist & Derrick Co.
American Manganese Steel Co.
American Steel & Wire Co.
American Tar Products Co.
American Wire Fence Co.
Ames Iron Works.
Ames Shovel & Tool Co.
Amiesite Asphalt Co. of America.
Anchor Post Fence Co.
Anthony Co.
Armco Culvert Manufacturers' Assn.

Asphalt Association, The.
Asphalt Block Pavement Co.
Asphalt Brick Co.
Athey Truss Wheel Co.
Atia Sales Corp.
Atlas-Imperial Diesel Engine Co.
Atlas Lumnite Cement Co.
Austin Machinery Corp.
Austin Manufacturing Co.
Austin-Western Road Machinery Co., The.
Autocar Co., The.

B

Baker Manufacturing Co., The.
Bakstad Crusher & Equipment Corp.
Baldwin Tool Works.
Banting Manufacturing Co., The.
Barber Asphalt Co., The.
Barber-Greene Co.
Barnes Manufacturing Co., The.
Barrett Co., The.
Barrymore Corp.
Bartlett & Snow Co., The C. O.
Bates Manufacturing Co.
Bay City Dredge Works.
Beach Manufacturing Co., The.
Beaumont Co., R. H.
Belknap, G. A.
Berry's Sons Co., James B.
Biehl Iron Works, Inc., The.
Bitumuls Corp.
Black & Decker Manufacturing Co., The.
Blackhawk Manufacturing Co.
Blair Manufacturing Co., W. M.
Blaw-Knox Co.
Bosch Magneto Co., Inc., Robert.
Broderick & Bascom Rope Co.
Brookville Locomotive Co.
Browning Crane Co., The.
Brown-Lipe Gear Co.
Buckeye Traction Ditcher Co., The.
Bucyrus-Erie Co.
Buda Co., The.
Buffalo-Springfield Roller Co., The.
Buhl Co., The.
Bunting Brass & Bronze Co., The.
Burch Corp., The.
Butler Bin Co.
Byers Machine Co., The.

C

C. H. and E. Manufacturing Co., Inc.
Carey Co., The Philip.
Carter Co., Ralph B.
Caterpillar Tractor Co.
Celite Products Co.
Chain Belt Co.
Chausse Oil Burner Co.
Chevrolet Motor Co.
Chicago Pneumatic Tool Co.
Chicago Road Machinery Co.
Chisholm-Moore Hoist Corp., The.
Christie Crawlers, Inc.
Cincinnati Car Co., The.
Cleveland Container Co., The.
Cleveland Crane & Engineering Co.
Cleveland Hardware Co., The.
Cleveland Tractor Co., The.
Cleveland Trencher Co., The.
Cleveland Wire Spring Co., The.
Climax Engineering Co.
Clinton Motors Corp.
Clyde Iron Works Sales Co.
Coleman Motors Corp.
Commercial Steel Casting Co., The.
Concrete Steel Co.
Concrete Surfacing Machinery Co., The.
Connenut Shovel Co., The.
Construction Machinery Co.
Continental Motors Corp.
Contractors & Engineers Monthly.
Cummer & Son Co., The F. D.
Cyclone Fence Co.

D

D-A Lubricant Co., Inc.
Dayton Steel Foundry Co., The.
DeWalt Products Co.
Differential Steel Car Co., The.
Domestic Engine & Pump Co.
Dot Lubrication Division, Carr Fastener Co.
Dow Chemical Co., The.

E

Eaton Axle & Spring Co.
Eisemann Magneto Corp.
Electric Wheel Co.
Elgin Corporation, The.
Endicott Forging & Mfg. Co., Inc.
Engineering News-Record.
Erie Malleable Iron Co.
Erie Steel Construction Co.
Etnyre & Co., E. D.
Euclid Crane & Hoist Co., The.
Everhot Manufacturing Co.

F

Fafnir Bearing Co.
Fairbanks, Morse & Co.
Farasey Manufacturing Co., The J. D.
Farrell-Cheek Steel Foundry Co.
Fate-Root-Heath Co., The.
Federal Motor Truck Co.
Ferry Cap & Set Screw Co., The.
Flory Manufacturing Co., S.
Foote Co., Inc., The.
Ford Motor Co.
Four Wheel Drive Auto Co., The.
Freeman Motor Co.
French & Co., A. W.
French & Hecht.
Fruehauf Trailer Co.
Fuller & Johnson Manufacturing Co.
Fuller & Sons Manufacturing Co.

G

Galion Allsteel Body Co., The.
Galion Iron Works & Mfg. Co., The.
Gardner-Denver Co.
Garst Manufacturing Co.
Gears & Forgings, Inc.
General Excavator Co., The.
General Wheelbarrow Co.
Geneva Metal Wheel Co., The.
Gilbert Manufacturing Co.
Gillette Publishing Co.
Godwin Co., Inc., W. S.
Good Roads.
Good Roads Machinery Co., Inc., The.
Goroco Mechanical Spreader Co.
Graham Brothers.
Grasselli Chemical Co., The.

H

Haiss Manufacturing Co., Inc., George.
Hamilton Manufacturing Co.
Hanson Clutch & Machinery Co., The.
Harley-Davidson Motor Co.
Harnischfeger Sales Corp.
Hastings Pavement Co., The.
Hayward Co., The.
Hazard Wire Rope Co.
Heil Co., The.
Heltzel Steel Form & Iron Co., The.
Hendricks Co., N. V.
Hercules Motors Corp.
Hercules Products, Inc.
Highland Body Manufacturing Co., The.
Highway Engineer and Contractor.
Highway Service Co.
Highway Shoulder Machine Co.
Highway Trailer Co.
Homelite Corp.
Hotchkiss Steel Products Co., Inc.
Huber Manufacturing Co., The.
Hug Co., The.
Hughes-Keenan Co., The.
Humphreys Manufacturing Co., The.
Hvass & Co., Inc., Chas.
Hyatt Roller Bearing Co.
Hydraulic Hoist Manufacturing Co.

I

Independent Pneumatic Tool Co.
Indiana Truck Corp.
Industrial Brownhoist Corp.
Ingersoll-Rand Co.
Insley Manufacturing Co.
International Cement Corp.
International Harvester Co. of America.
International Engineer.
Irving Iron Works Co.

J

Jaeger Machine Co., The.
Johnson Co., C. S.
Jones Superior Machine Co.
Joy Manufacturing Co.

K

Keystone Driller Co.
Killifer Manufacturing Co.
Kinney Manufacturing Co.
Klauer Manufacturing Co.
Knickerbocker Co., The.
Koehring Co.
Kwik-Mix Concrete Mixer Co.

L

Lakewood Engineering Co., The.
LaPlant-Choate Mfg. Co., Inc.
Larrabee-Deyo Motor Truck Co.
Lauson Manufacturing Co., The John.
Leach Co.
LeBlond-Schacht Truck Co., The.
Leece-Neville Co., The.
LeRoi Co.
Leschen & Sons Rope Co., A.
Lidgerwood Manufacturing Co.
Link-Belt Co.
Linn Manufacturing Corp., The.
Little Red Wagon Manufacturing Co.
Littleford Brothers.
Lufkin Rule Co., The.
Lycoming Manufacturing Co.

M

Maccar Truck Co.
MacLean-Fogg Lock Nut Co.
Macleod Co., The.
Macwhyte Co.
Manitowoc Engineering Works.
Manufacturers Record.
Marion Steam Shovel Co., The.
Marion Steel Body Co., The.
Marlow, A. S.
McEverlast, Inc.
McKiernan-Terry Drill Co.
Meade-Morrison Manufacturing Co.
Meadows, Inc., W. R.
Metal Forms Corp.
Metal Traffic Marker Corp.
Metalweld, Inc.
Metropolitan Body Co., The.
Midwest Locomotive Works.
Milburn Co., The Alexander.
Minneapolis Steel & Machinery Co.
M and M Wire Clamp Co.
Mohawk Asphalt Heater Co.
Monarch Tractors Corp.
Morris Machine Works.
Morse Chain Co.
Motor Improvements, Inc.,

N

National Carbon Co., Inc.
National Colortype Co., The.
National Highways Association.
National Hoisting Engine Co.
National Paving Brick Manufacturers' Assn.
National Rock Asphalt Corp.
National Steel Fabric Co.
National Traffic Signal Co.
Nelson Iron Works, Inc., N. P.
New Departure Manufacturing Co., The.
Niagara Concrete Mixer Co.
Northwest Engineering Co.
Novo Engine Co.
Nugent Steel Castings Co., The.

O

O'Connell Motor Truck Co.
Ohio Power Shovel Co., The.
O. K. Clutch & Machinery Co.
Olsen Testing Machine Co., Tinius.
Orton Crane & Shovel Co.
Osgood Co., The.
Owen Bucket Co., The.

P

Page Engineering Co.
Page Steel & Wire Co.
Park Drop Forge Co., The.
Parsons Co.
Perfection Steel Body Co.
Perfex Corp.
Perry Co.
Pierce-Arrow Motor Car Co., The.
Pierce Governor Co., The.
Pioneer Gravel Equipment Mfg. Co.
Pit and Quarry.
Pittsburgh Plate Glass Co.
Pittsburgh Testing Laboratory.
Pneu-Hydro Road Machinery Co.
Pontiac Tractor Co.
Portland Cement Association.
Prest-O-Lite Co., Inc., The.
Productive Equipment Corp.
Public Works.

R

Ramsey Chain Co., Inc.
Ransome Concrete Machinery Co.
Rawls Manufacturing Co.
Ray-Signs Corp.
Relay Motors Corp.
Reo Motor Car Co.
Republic Iron Works.
Republic Truck Sales Corp.
Ric-Wil Co.
Riddell Co., W. A.
Rightway Corp., The.
Rock Products.
Roderick Lean Co., The.
Rogers Brothers Corp.
Rome Manufacturing Co.
Rotary Snow Plow Co.
Russell Mfg. Co.
Russell Grader Manufacturing Co.
Ryan Manufacturing Corp.
Ryerson & Son, Inc., Joseph T.

S

Safety Engineering.
Sauermann Brothers, Inc.
Sawyer-Massey, Ltd.
Schaefer Wagon Co., The Gustav.

Schramm, Inc.
Selden Truck Corp.
Shaw-Enoche Tractor Co.
Shunk Manufacturing Co.
Sidney Steel Scraper Co.
Simons Paint Spray Brush Co.
Simplicity Engineering Co.
Sivyer Steel Casting Co.
SKF Industries, Inc.
Smith Engineering Works.
Smith Trailer Corp.
Smith Co., The T. L.
Snap-On Wrench Co.
Snell Metal Sign Co.
Solvay Sales Corp.
South Bend Lathe Works.
Southwark Foundry & Machine Co.
Speeder Machinery Corp.
Star Drilling Machine Co., The.
Staynew Filter Corp.
Stearns Motor Manufacturing Co.
Sterling Machinery Co.
Stockland Road Machinery Co.
Stoile Spreader Sales Co.
Stover Manufacturing & Eng. Co.
Streich & Brother Co., A.
Sullivan Machinery Co.
Superior Body Corp.
Szekely Corp., O. E.

T

Taylor-Wharton Iron & Steel Co.
Texas Co., The.
Thew Shovel Co., The.
Timken-Detroit Axle Co., The.
Timken Roller Bearing Co., The.
Titeflex Metal Hose Co.
Toledo Pressed Steel Co., The.
Toncan Culvert Manufacturers' Assn.
Trackson Co.
Transit Mixers, Inc.
Truck Mixer Co.
Truscon Steel Co.
Twin Disc Clutch Co.
Tyler Co., The W. S.

U

Universal Concrete Products Co.
Universal Crane Co., The.
Universal Crusher Co.
Universal Power Shovel Co.

W

Wallace & Tiernan Co., Inc.
Walter Motor Truck Co.
Wapnat Gear Works, Inc.
Waukesha Motor Co.
Wausau Iron Works.
Wehr Co.
West Process Pavement Co.
Western Crucible Steel Casting Co.
Western Metal Specialty Co.
Western Wheeled Scraper Co.
Wheeling Mold & Foundry Co.
White Co., The.
Whitehead & Kales Co.
Wiard Plow Co.
Wickwire Spencer Steel Co.
Willett Manufacturing Co.
Williams Co., G. H.
Williams Patent Crusher & Pulverizer Co.
Williamsport Wire Rope Co.
Winsor Co., The.
Winsor Tractor Equipment Corp.
Wisconsin Foundry & Machine Co.
Wisconsin Motor Manufacturing Co.
Wood Hydraulic Hoist & Body Co.

Y

Young Radiator Co.

Z

Zenith Detroit Co.

Status of Gas Tax

A 2-ct. gasoline tax went into effect in Massachusetts Jan. 1. This leaves New York the only state in which a gasoline tax has never been adopted. Illinois adopted a 2-ct. tax in 1927 but it was held unconstitutional. This leaves the status of the gas tax as follows:

5 cts.	Six states
4 cts.	Twelve states
3½ cts.	One state
3 cts.	Fourteen states
2 cts.	Thirteen states
No tax	Two states

The six states having a 5-ct. gas tax are: Arkansas, Florida, New Mexico, South Carolina, and Virginia.

The British Road Situation

The report of the Administration of the Road Fund for Great Britain for 1927-28 reveals the process by which the roads are more and more assuming a national character, and coming under central control; no longer do local conditions only apply. According to a report by Albert Halstead, U. S. Consul General in commerce reports, main routes are being made out of country lanes; weak bridges are everywhere being strengthened, and new roads and by-pass roads are being planned with a view to the growth of towns and villages. In the year under review, standardized lighting for all road vehicles was established.

Census of Traffic.—The huge increase in recent years in the volume of traffic has brought an entirely new classification of the roads of Great Britain, as is to be seen in the census that being taken by the Ministry of Transport over the current year. For this, 24 points have been selected, representing eight classes of districts, which typify industrial, agricultural, sporting, tourist, and dock areas, residential suburbs, seaside resorts, and inland holiday centers.

At each of these a 24-hours' record of traffic is being taken on 42 days, evenly distributed over the year. Each day of the week will figure six times in the complete record, and by this means it is hoped that a representative picture will be obtained of the daily and seasonal fluctuations of traffic. These particulars, it is stated, should also prove of great value in arriving at an estimate of highway costs in relation to the local traffic.

Millions of Pounds Sterling for New Roads.—The total receipts of the Road Fund from all sources amounted to £20,348,503 compared with £18,232,948 in the previous year. The total net payments under grants during the year amounted to £18,743,371, and the total net payments for all purposes during the same period amounted to £31,703,-364. This last sum included £12,000,-000 transferred to the Exchequer under Section 49 of the Finance Act 1927.

For 1928-29 the estimated net revenue available for the Road Fund is £20,700,000, of which it is proposed to devote £12,537,500 to classified roads, £2,900,000 to rural roads, and £1,000,000 to works, including the Thames bridges recommended by the Royal Commission on Cross-River Traffic.

The increased importance of rural areas is illustrated by the added mileage scheduled for the purpose of maintenance grants. That mileage is now 55,053, an increase of 14,120 over the preceding year. The process of "Maining" district roads has also been steady and continuous, and during the year about 500 miles of main roads have been thus treated. By-pass roads already in existence cover 226 miles. Of arterial roads in the greater London area, 30 miles were completed during the year, and opened to traffic. Other schemes include the 39 miles of road from Glasgow to Edinburgh, and the Perth-Inverness road, a stretch of 77½ miles, which has now been completed.

Motor Vehicles and Driving Licenses Receipts.—Receipts from the taxation of road vehicles amounted during the year to £23,456,378. The number of motor vehicles on the roads has jumped from 873,700 in 1921, to 1,898,500 in 1927, and the approximate number of driving licenses from 2,132,000 to 2,349,-000. The total number of mechanically-propelled vehicles of every kind rose from 1,729,505 in 1926 to 1,899,876 in 1927. The increase in the horse-power class, however, by 15 per cent, was entirely on cars below 23 horse-power. Contrasted with this is a decrease, outside of London, of the number of taxi-cabs, and of vehicles seating not more than 14 persons, amounting to 13 per cent. Other hiring vehicles have increased by 16.9 per cent.

Road Accidents.—Of 586 serious road accidents, occurring outside the Metropolitan area, which were investigated by the Ministry of Transport, it was found that 15 per cent were due to a mechanical defect in the vehicle, 16 per cent to unsatisfactory road conditions, 58 per cent to error or negligence on the part of the driver, and 11 per cent to other causes. In the last catagory comes the pedestrian, who was responsible for only 24 out of the total number of accidents.

Route of Pan American Highway Through Mexico

According to a report from Acting Commercial Attache Albert F. Nufer, Mexico City, to the Bureau of Foreign and Domestic Commerce, Mexico, Mexico has definitely decided on the route of the road that will form part of the Pan American Highway. The highway will enter Mexico at Laredo, continuing south through Monterrey, Ciudad Victoria, Valles (with a branch to Tampico), Pachuca, and Mexico City, and then southeast through Puebla, Oaxaca, the Isthmus of Tehuantepec, to the border of Guatemala at a point to be decided on later.

The stage of construction on this road is as follows: 500 kilometers of the total 1,250 kilometers of the highway from Laredo to Mexico City have been completed. The road from Mexico City to Peubla has been opened to the public for quite some time, and considerable headway has been made on the Puebla to Caxaca road. Construction of the unfinished sections of the Mexico City-Laredo highway is proceeding rapidly and it is expected that within a year a passable road will be opened. As soon as the Mexico City-Laredo road has been completed, attention will be given to the Mexico City-Guatemala division.

What Can Be Seen at the Cleveland Road Show of the A. R. B. A.

Notable Improvements Cause Closer Cognizance of Unit Costs

Interest in the problems that are a part of better highway construction and maintenance draw progressive road builders together once every year. In connection with these annual meetings, where the newest road building methods are eagerly discussed, a road show of the latest improved models of road building machinery is also held.

For highway engineers, contractors, road commissioners, everyone interested in roads or road building, regardless of the direction the interest takes, there is always inspiration in the Road Show exhibits.

An important improvement that is causing older machinery to become rapidly obsolete is the installation of devices for removing wear and play in the joints and bearings surfaces. In this improvement various schemes are employed for removing this slack; clamps, fittings, bearings, enclosed bearings, adjustments, etc. Construction machinery is advancing to the stage occupied by the automobile, with the exception of the automobile's fine upholstery and highly polished body.

Another noticeable improvement in methods is the growing substitution of machinery for labor, especially heavy labor. Mass production policies are being introduced and are an important economic item. All this improvement means that the contractor and the engineer must take cognizance of the importance of unit costs. Depreciation, management, overhead and repairs thrust themselves forward to an increasing degree, in the calculations of the cost. In the final analysis, all this improvement is made for the simple purpose of reducing unit costs. Competition forces this reduction.

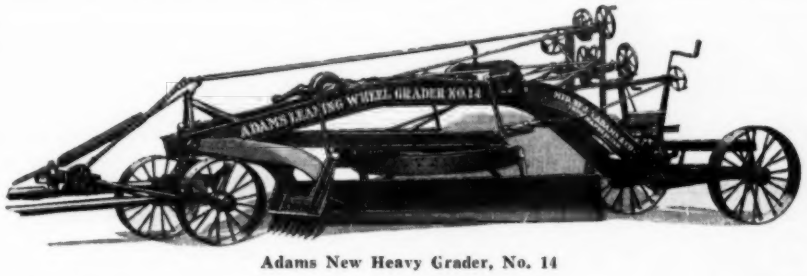
As it has been in the past, so we may expect it to be in the future. We may continue to look forward to new inventions and improvements in the road building and construction industries. Increasing application of mass production machinery along with methods and machinery for the construction of low cost year-round roads challenge the initiative and research ability of American manufacturers and engineers.

The following pages contain information from as many of the exhibitors, on their machinery to be shown, as the editor was able to get. In these various writeups may be found descriptions of some of the improved equipment to be displayed.

J. D. Adams Exhibits Two New Models

J. D. Adams and Company's exhibit at the show will be in space WW-70, which is just inside the door in the West Wing. Mr. E. E. Christena will be in charge, as usual, assisted by a number of representatives.

The outstanding unit of this exhibit will be Adams leaning wheel grader No. 14, a new heavy duty 12-ft. grader, furnished with or without scarifier. This is one of the largest, if not the largest, grader ever put on the market. It involves distinctly new construction and control features, including a new type of frame construction and an entirely new type of blade control.

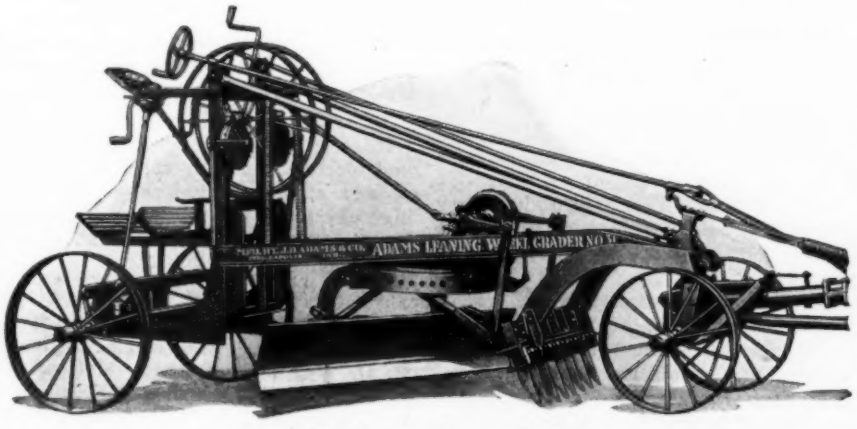


Adams New Heavy Grader, No. 14

The absolute frame rigidity, claimed by the manufacturer, is made practical by using a large ball and socket in the front truck instead of a fifth wheel.

The blade lift gears are mounted on the frame directly over the blade. The lift gears, of standard worm and gear design, are operated through 8 to 1 reduction spur gears.

The drawbar and blade are shifted sidewise by means of a heavy bracket traveling on a machine cut screw operated by bevel gears from the operator's plaftorm. The blade is reversed from the platform through a bevel gear control which operates a pinion engaged in a gear track riveted to the inside of the semicircle. Alemite lubrication system and Hyatt roller bearings are standard equipment.



Adams No. 31, First Time at Road Show

Adams leaning wheel grader No. 31, a new comparatively light scarifier grader which is finding considerable favor among contractors for working the sub-grade between forms, will also be shown for the first time.

It is claimed that this 7-ft. grader, with or without the scarifier, is capable of splendid ditch work, and particularly with the scarifier, which may be used in connection with or independently of the blade, it is a very good maintenance grader.

The blade lift and scarifier control gears of the No. 31 are machine-cut, closely housed, and run in oil. The worm gears have special end-thrust bearings adjustable to eliminate end play. The gears are keyed to machine-finished shafts to which are also keyed drop forged lift arms. The lift links for both the blade and scarifier controls

are of one-piece, forged-steel construction, having machine-finished ball and socket joints at either end, with split bearings adjustable for wear. (The scarifier is raised and lowered by one control and one set of gears with a 4 to 1 spur gear reduction for leverage.)

In addition to the above mentioned features the new No. 31 is of the distinctively rigid, triangular design which has proved so highly successful in other Adams graders of the lighter weight type. In this design an A shaped drawbar serves also as the main frame, being connected to the front axle by a ball and socket joint which takes the place of a fifth wheel. The rear end of the drawbar is connected to a lifting frame by means of three vertical guides on the front side of the frame. The lifting frame rests directly on the rear axle and is supported in its vertical position by two struts between the top of the frame and the front end of the drawbar. The rear end of the drawbar is suspended from and is controlled by the lifting mechanism. The rear member of the drawbar (a 1½-in. square steel bar turning in trunion bearings) works closely but freely up and down between the vertical guides on the front of the lifting frame. This permits any desired adjustment of the blade as either side of the drawbar may be raised or lowered independently.

In addition to the two new machines described above they will have an Adams motor grader No. 10, introduced this year, using McCormick-Deering 10-20 tractor. This machine also introduced several distinctive new features in motor grader construction, including a new type of frame construction and a new blade control which is not only easier but faster than controls heretofore used.

Alabama Rock Asphalt, Inc., at Road Show

Samples of Margerum asphaltic limestone and pavement constructed with this material will be exhibited by Alabama Rock Asphalt, Incorporated, at space SEH-15 in the South Exhibition Hall.

Of special interest will be samples taken from a 19-mile state highway project on which a 4-in. black base and 1-in. Mergerum hot mix top are being laid on an old gravel road.

There will also be samples of Margerum cold mix pavement in the exhibit. The cold mix pavement may be manufactured at the site of the paving work, or the mixture may be purchased from the company ready to lay. Margerum cold mix handles readily from cars and, as it does not lump up or harden in transit, is a very economical material to spread and lay.

Samples of the native asphaltic limestone will be shown as it comes from the quarries, also after it has been crushed and pulverized. Descriptive literature and specifications for both Margerum hot mix and cold mix will be available. The company will be represented at Cleveland by W. L. Caldwell, J. H. Conzelman, J. H. Mayer and W. M. Shannon.

Allis-Chalmers Exhibits New Crusher

Allis-Chalmers Mfg. Co. will exhibit at the Cleveland Road Show featuring an operating exhibit of the Newhouse Style B crusher for high capacity and low crushing costs. This crusher has a large receiving opening, short rigid main shaft and rapid crushing stroke. The result of this high speed crushing stroke is high capacity with a uniform product at a minimum of power per ton of material crushed. The machine is self-contained with vertical motor.

The forged steel heat treated main shaft is of heavy proportions, hollow bored for strength and passage of the drive shaft from the motor.

Lubrication is by external motor driven centrifugal pump with oil filter and cooler. The crusher is of heavy construction to meet the most severe crushing conditions. Concaves are reversible end for end. The machine is arranged for three point suspension by cables to the framework of the building, thus saving building space and foundation expense and eliminating building vibration.

The perfected Allis-Chalmers Newhouse Style B crusher is the result of over seven years' work and study. It is made in three sizes: 7 in., 10 in. and 14 in. receiving opening.

The company will be represented at Cleveland by the folowing representatives: Mr. H. Schifflin, Manager, Crushing and Cement Division; R. C. Newhouse, Chief Engineer; C. R. Beck, Sales Engineer; G. W. Shores and A. Goldberg of Milwaukee; W. E. Keine, New York office; J. M. Johnson, Chicago office; also the following representatives from the Cleveland office: A. H. Wyman, manager, J. T. Mueller, V. E. Walters, W. F. Sheriff, F. A. Miller and M. V. Bailliere.

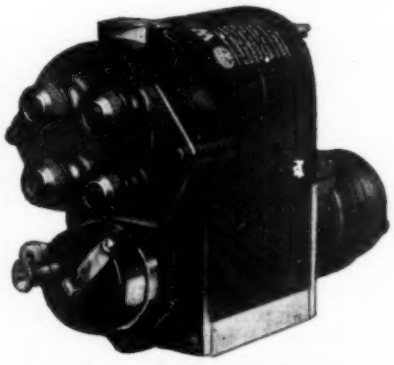
AW Traffic Treads on Bridge Floor Model

The Alan Wood Iron and Steel Company's exhibit at the Road Show will consist of a working model bridge floor with an installation of AW traffic treads thereon. This will follow very closely the design shown on the front cover of this issue of ROADS AND STREETS.

In addition to the AW traffic treads, they will feature their AW Diamondette floor plates which are proving successful for running boards and step plates for operating cabins and platforms as well as running boards for automobiles and automotive machines.

American Bosch to Show Magnetos

The American Bosch Magneto Corporation, Springfield, Mass., will display their line of magnetos and accessories in booth No. EH-22. The following representatives will be on hand to meet



Bosch Magneto to Be on Display

visitors: Mr. A. H. D. Altree, vice-president, Mr. C. J. Lang, vice-president, Mr. E. C. Peck, sales manager, Mr. F. J. Bartella, Mr. G. H. Cherry, Mr. E. S. Fraser, Mr. F. N. Perry, Mr. Max Tost, and Mr. E. A. Lynch.

American Casting Company Shows Culvert Pipe

The American Casting Co. of Birmingham, Ala., will be at the Road Show exhibiting their Spi-Cor and Lock Joint cast iron culvert pipe. Shipments of both lock joint and spiral corrugated cast iron pipe have been made to all parts of the United States. The force at the foundry has increased from 10 or 15 men in 1904 to an average of 250 in 1927. Branch offices have been opened in New York City, Harrisburg, Pa., Boston, Mass., and Green Bay, Wis. Warehouses have been established at North Fond du Lac, Wis., Boston, Mass., and Harrisburg, Pa.

American Steel and Wire Company Display

The American Steel and Wire Company will exhibit at the American Road Builders' Show in space AA-61.

Their display will consist of concrete reinforcement fabrics, triangular mesh and electric weld for reinforcement of streets and highways, steel posts for highway signs and snow fences, American wire rope, and perfected highway guard cables.

The following representatives of the company will be in attendance:

B. S. Pease, O. T. Allen, P. T. Coons, H. D. Worthington, H. E. McCann, R. C. Pierce, C. T. Gilchrist, R. E. Hinman, R. C. Groesbeck, A. T. Merriman, W. H. Cordes, and R. E. Francisco.

American Hoist & Derrick Co. Shows 1-Yd. Shovel

The American Hoist & Derrick Co.'s booth at the Road Show will be WW-83. At this space they will have a gasoline operated American Gopher all steel, SKF ball bearing equipped, shovel-crane with a shovel boom and 1-yd. dipper. This is the same machine that appeared at the Road Show in 1928. A number of refinements in the design and construction of various parts add to the superiority of the machine. The American Gopher shovel-crane is regularly equipped with a Waukesha 80 hp. motor.

American Gopher on Display by American Hoist & Derrick Co.

Tarmac to Have Rest Lounge

The American Tar Products Company, Pittsburgh, Pa., will have booth AA-13, and this booth will be arranged as a lounge, where customers and friends will be welcomed. A number of representatives will be present, who will be glad to discuss Tarmac and road work in general with those who want information along these lines.

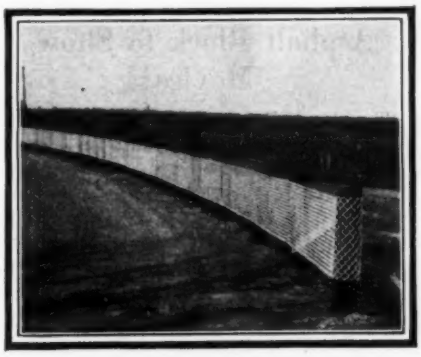
The manager of the Tarmac department, Mr. Paul L. Griffiths, will be in charge of this booth.

American Wire Fence Co. to Show Guard

The American Wire Fence Company, 7 S. Dearborn St., Chicago, will show their American Life net road guard, together with many photographs showing typical installations throughout the country, and will distribute literature fully describing this product and its uses. This booth will occupy space SEH-28.

With the individual motorist contributing materially to construction and maintenance of highways through gas taxes in the greater majority of states, he is coming more and more to demand the best protection that can be afforded him at danger points on the roads, such as curves, fills, bridges approaches, etc. American life net road guard gives him this protection and the American Wire Fence Company say that their product is serving the motorists in more than 30 states in this country in addition to several foreign countries.

Guard rail has long been recognized as a necessity among the leading highway engineers, but with many states increasing their speed limits, and superelevating their curves to help the driver maintain that speed, every curve and embankment becomes a menace to traffic. The old-fashioned rigid post-and-rail guard, while being better than no guard at all, is now recognized among leaders in highway design as being practically obsolete, since this modern type of protection that cushions the impact, saves the car, and its burden of human life, can be erected complete at practically the same cost.



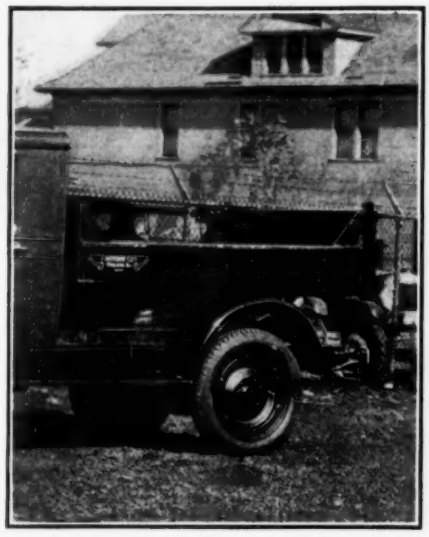
The American Life Net Road Guard

Anthony Announces New Body

What promises to revolutionize the style of single batch capacity dump bodies for light duty trucks will be introduced to road paving contractors at the coming Good Roads Show by the Anthony Company, Inc., Streator, Ill.

This new dump body is an addition to the roller rocker gravity line manufactured by that concern.

Deriving its lifting power from the motor through a power take-off, the new model is known as a rotating (power driven) hoist. Application of this power is simple and easy. Lack of complicated parts with their attendant need for replacement is an outstanding feature in its construction. Low loading height and increased loading area in the box has been endorsed by leading paving contractors of the country. The general characteristics, such as electric welding, one piece boxes, structural steel understructures, double acting tailgates, high dumping clearance and ample underbody cross braces, conform to the Anthony standards. Production is now under way and advance orders will be filled rapidly as possible.



New Body Announced by the Anthony Company

By reason of their manufacturing facilities and the simplicity of construction, the Anthony Company are enabled to offer this power lift body at a price within range of present gravity body types. Contractors and automotive dealers will find this body in booth WW-61, West Wing, displayed with other bodies of the Anthony line.

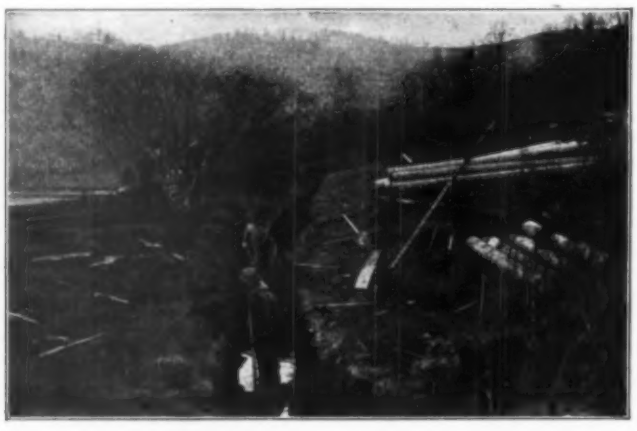
W. C. Anthony, president, B. B. Howard, sales manager, W. V. Tomlinson, J. H. Monning, E. S. Kriegh, E. L. Flanigan and C. F. Hartman will represent the company and will be registered at the Statler Hotel.

Armco Exhibit Features Subdrainage

A recent development in highway work is a growing realization of the importance of subdrainage and the greater use made of it in protecting roads. This detail of highway design affects the stability of pavements and structures and is frequently a factor in the control of landslides.

Because of the importance of this subject the central feature of the exhibit of the Armco Culvert Manufacturers' Association, Middletown, O., at the National Good Roads Show is Armco perforated iron pipe, a product especially designed for subsurface drainage. This pipe, which is corrugated iron perforated in the valley of each corrugation for a portion of its circumference, is also exhibited at this show.

The Armco display is in space EH-17 with Anton S. Rosing, Publicity Manager, in charge. Others in attendance are W. F. Moehlman, J. S. Neibert, T. M. Neibling, H. J. McKeever, W. H. Spindler and Dr. G. E. Ladd.



Installing an Armco Perforated Pipe for Landslide Prevention in West Virginia

is well adapted to subdrainage problems because of its great strength, its safety against surface impact and frost action, its resistance to disjointing, and its high drainage capacity.

Evidence presented of the efficiency of Armco perforated pipe includes installations involving landslide prevention along highways and railways, protection of bridge abutments, stabilizing of roadbeds, golf course improvement and airport drainage. The satisfaction obtained from this type of drainage is due to its uniform dependability and freedom from trouble.

Another highway problem which has been given attention by Armco engineers is that of culvert erosion, it having been found that culverts of all types wear out first in the bottom because of the scouring action of the stream. Often the bottom will be entirely gone while the rest of the structure is unharmed. The solution developed by Armco engineers for this problem is a culvert of balanced design in which the entire structure is given a uniform life throughout. The bottom is reinforced against its concentrated wear by a specially developed and exceedingly tough, yet heat resistant bituminous pavement. This product is the Armco paved invert culvert which

Replica of King Tut's Inner Coffin Displayed

The Asphalt Association, exhibiting in booth EH-1 at the American Road Builders' Convention in January, will illustrate the use of asphalt in highway construction. The feature will include a replica of the marvelous inner coffin of King Tutankh-Amen, typifying asphalt of ancient vintage. It serves the living today as a preserver of the world's highways. It saved from the destroying touch of time, King Tutankh-Amen and his royal splendor. Thus we have evidence of the slogan "Asphalt proved through the ages."

Photographs and charts will be shown and publications distributed.

Asphalt Block to Show Movies

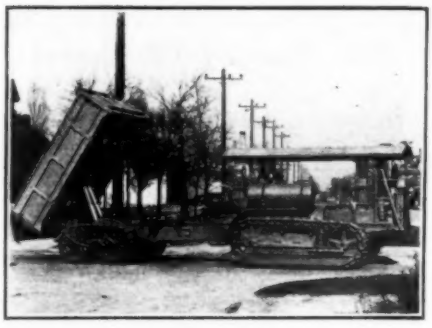
The Asphalt Block Pavement Co., in booth AA-63, will show sample blocks, photographs, literature and moving pictures of their class of work. This concern will be represented by Frank W. Klett, W. D. Short and Fletcher Rogers.

Athey Truss Wheel Co. Shows Dump Trailer

The Athey Truss Wheel Co. of Chicago, Ill., will be at the Road Show with a 3-way dump trailer showing the Athey truss type tracklaying crawlers.

The Athey truss wheel, 3-way dump trailer is an all purpose unit, it dumping to the right, to the left or to the rear. Dumping is controlled by the tractor operator. The doors or gates open and close automatically.

It is furnished in two different sizes,



Athey Truss Wheel 3-Way Dump Trailer

a 4 to 5-yd. body on a 10-ton chassis and a 7 to 8-yd. body on a 15-ton chassis. The side gates down fold and the load is discharged over and clear of the wheels. Hoist is direct lift, telescoping cylinders mounted on a steel arched casting, operating on double oscillating trunnions at top and bottom.

These dump trailers are designed to operate behind standard crawler tractors.

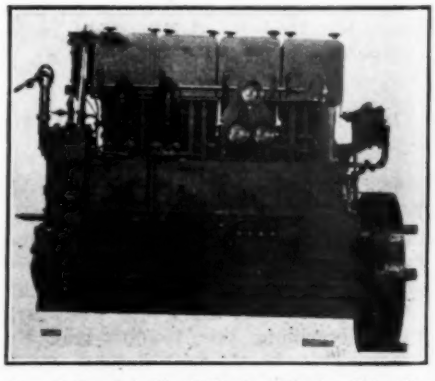
Atlas-Imperial Shows Diesels

The Atlas-Imperial Diesel Engine Co., Oakland, Calif., will display a 4-cylinder 6½x8½ industrial engine at the coming Cleveland Road Show.

The engine is said to be the culmination of a development period extending over seven or eight years, on Diesel engines suitable for use in shovels, drag lines, clam shells, excavators, locomotives, for driving crushers, screening plants, elevators, etc.; in general, for application to all classes of industrial service where rugged construction and utmost reliability are to be expected.

The engine is of the dustproof type and the design permits of the utmost accessibility. The engine employs the rail system of mechanical injection developed by the Atlas-Imperial Diesel Engine Co., which is said to have proved so universally satisfactory in all parts of the world.

This engine will burn fuel oils originating from all oil fields, say the manufacturers. The proportions of the engine are extremely rugged, as experi-



New Industrial Diesel Engine Displayed by the Atlas Imperial Diesel Engine Co.

ence has proved necessary for this class of service. Starting is effected by compressed air, and is positive, even in the coldest weather. No auxiliary heating devices are necessary.

Crankshaft, connecting rods, piston and bearing construction are by a design developed by many years' experience and dictated by the usages of a very severe service.

Lubrication is effected by a pressure system circulated by means of positive pumps, the oil being maintained under a pressure of from 5 to 10 lb. per sq. in. Lubricating oil filters are inserted in the system to maintain the lubricating oil at its highest possible lubricating value. In addition to the circulation system, a fresh oil system of lubrication is applied, which supplies a small quantity of fresh oil to the cylinder walls, supplementing the lubrication to the pistons effected by the throwoff from the cranks. The fuel oil system is of the constant pressure type, which experience has shown to be the best system for varying loads and speeds. In the fuel system are inserted proven filtering devices. The system of lubrication is an example of extreme simplicity, easily understood and cared for by the average operator.

The exhibit will be in charge of G. N. Somerville of the Oakland factory and Mr. F. H. Kilberry and Mr. E. V. Parker of the Central Division Branch, Chicago.

Austin-Western Exhibits Newly Developed Equipment

The Austin-Western Road Machinery Company, in booth No. WW-111, will exhibit seven pieces of equipment. Three of these are of special interest because they represent entirely new developments in the Austin-Western line in the road machinery field.

First and foremost will be the Austin dual drive motor grader which has already caused much interested comment. The model exhibited will be built around a McCormick-Deering 10-20 power plant.

Among other things, the dual drive, they claim, provides more power than has ever before been obtained from a similar power plant, greatly increased traction, less wear through the elimination of friction, and the ability to operate over softer, wetter ground than has been possible with 2-wheel drive machines.

Another entirely new machine, being displayed for the first time, is the Austin Cadet, a 5-ton, factory built, pup-sized roller, very similar in appearance to the well known 10-ton Austin Autocrat. Its exceptionally short wheelbase permits great freedom in operating between forms and the Cadet transmission with 3 speeds forward and reverse gives increased handling ease.

A third innovation is the Western 5-yd. crawler wagon. In design this closely follows the Western 7-yd. and 10-yd. crawler wagons. The advantage of the smaller wagon with the same features (easy dumping and ability to work over any ground regardless of its condition) possessed by the larger wagons will be apparent to everyone interested in earth handling.

Other machines displayed will include the 10-ton Austin Autocrat roller with power steer and scarifier, the Austin Mammoth Senior leaning wheel grader with Rip-Snorter scarifier, the Western No. 55 grader with scarifier, and the Western motor grader attachment for the No. 20 Cletrac, with front scarifier and cab.

The exhibits will be in charge of Mr. William Cornwell.

New Austin-Western Dual Drive Motor Grader

Autocar Exhibits Ready Mixed Concrete Body on Chassis

One of the most significant developments in road building machinery during 1928 has been the perfection of truck bodies for carrying ready-mixed concrete. An improved body of this type will be a feature of the Autocar Company's exhibit at the Convention of the American Road Builders' Association which opens four-day sessions in Cleveland on January 14.

Autocar Trail Blazer Equipped with Autocar Rotary Hoist Body

The Autocar Company, motor truck manufacturers of Ardmore, Pa., conducted an exhaustive investigation to determine the most efficient type of machinery for hauling ready-mixed concrete. They selected the Good Roads-Clinton concrete carrier, and will accord it the place of honor in their exhibit. This will be the first time the Autocar Company has ever exhibited their chassis with such equipment.

The carrier will be mounted on a standard 5-ton, 6-cylinder, type CM Autocar chassis, having a wheelbase of 162 inches. The carrier itself is notable for its strength and simplicity. It consists of a cylindrical tank of 1½ or 3 cu. yds. capacity. The inside walls and ends of the tank are smooth and entirely free of flights, supporting shafts or obstructions. After loading, it is hermatically sealed and slowly revolved until ready to discharge. The rolling action eliminates all segregation but causes more complete hydration. As long as three hours after loading, the batch will have the same consistency it had when it left the central mixing plant, it is claimed.

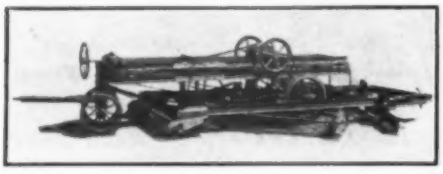
The carrier is powered by a motive unit entirely separate from the power plant of the truck. An 8-horse-power Le Roi two-cylinder motor, with throttle control, is mounted on the chassis to furnish the power for the revolving motion of the carrier.

The Autocar Trail Blazer, a 6-cylinder, 3-ton, dump truck with a 114-inch wheelbase, which was the feature of the company's exhibit last year, will be exhibited again at this show, but with several improvements. The newly-developed Autocar rotary hoist permits the 3½-yd. body to be raised to an angle of 60 degrees thus facilitating the dumping of any clinging load.

The third unit in the Autocar exhibit will be a three-ton truck, varying from the Trail Blazer only in the fact that the 6-cylinder engine is located conventionally, under a hood out in front, thus increasing the wheelbase from 114 inches to 158 inches. It will be equipped with a 3½-yd. body with Wood hydraulic hoist. It is designed for the contractor to whom conventional appearance is a more essential factor than short wheelbase handiness.

Baker Exhibits Automatic Road Maintainer

The Baker Manufacturing Co., Springfield, Ill., are exhibiting in booth WW-81, in the West Wing of the Good Roads Show. They will show as many products as their space will permit. Baker Maney scrapers with all the latest improvements will be shown. The



Baker Road Maintainer with Scarifier Attachment

Baker one man automatic road maintainer, with scarifier attachment, will be shown for the first time. Baker one man automatic rotary scrapers will be exhibited in four sizes for any tractor. Several types of Baker snow plows will also be on exhibition. The method of showing how the maintainers and scrapers operate will be interesting to those who contemplate purchasing these types of equipment.

The exhibit will be in charge of Mr. J. G. Miller, Vice-President and Sales Manager, assisted by other officers and district representatives.

Bakstad Shows Rock Crusher

The Bakstad Crusher & Equipment Corporation, Chicago, Ill., will have an interesting exhibit in space SEH-2, where will be shown one of their patented 3-jaw rock crushers.

This machine is in reality three crushers in one unit as it is provided with one set of crushing jaws at the top, for primary crushing and two additional sets of jaws directly below, where secondary reduction takes place. The three sets of jaws, however, are actuated by the single mechanism otherwise required to operate the ordinary type of crusher and is as accessible for adjustments or replacements of parts as if it contained only the one set of crushing jaws.

This type of crusher, therefore, affords a greater ratio of reduction without sacrificing capacity and makes it unnecessary in most installations to operate separate units for primary and secondary reduction.

As an illustration, a size crusher having a receiving opening that will accommodate a rock 12 in. in the smallest dimension can be adjusted to produce ½ in. material or any intermediate size desired up to 3 in.

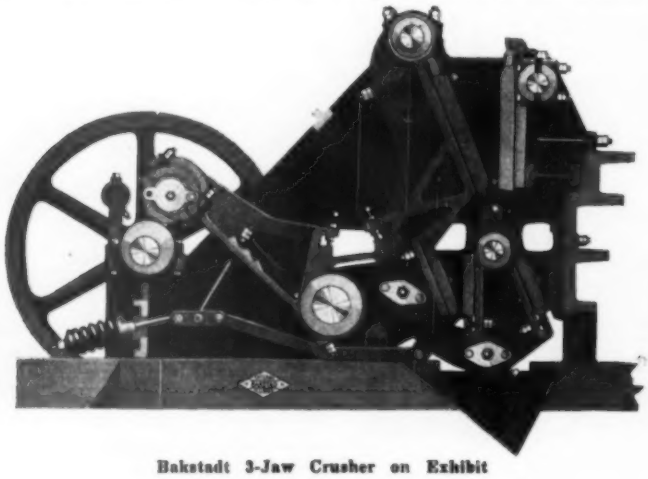
Changing the main adjusting toggle, automatically adjusts all three crusher openings, whereas the stationary jaw of the primary crusher is provided with an independent adjustment if required, to equalize the capacity of primary and secondary crushing paths.

Of several stock sizes manufactured by this company, the one to be exhibited at the Road Show has a receiving opening of 8 in. x 20 in. While this size is applicable in stationary installations it is also one of the sizes popular for portable plants and will be shown mounted on a 4-wheel truck.

The Bakstad patented 3-jaw crusher meets the requirements created by the demand for finer crushed materials for use in construction work and has well demonstrated its good qualities and superior performance in a large number of installations in a varied field of applications.

The crushers are constructed of open hearth cast steel throughout, manganese steel lined and provided with dust proof, high pressure lubricated bearings, of an improved design.

A new and comprehensive twenty-four page catalog will be distributed at the Road Show.



Bakstadt 3-Jaw Crusher on Exhibit

Barber Asphalt to Show Curcrete

The Barber Asphalt Company, with general offices in Philadelphia, who have been represented at the Road Show for many years, are again represented and have space No. AA-51 on the main floor of the Public Auditorium.

This year, Curcrete, an emulsion of bitumen manufactured specifically for the purpose of curing concrete is being featured by The Barber Asphalt Company. Curcrete does not require the use of any other curing agent but replaces water, burlap, hay, earth, chemicals and all other materials heretofore in use for this purpose.

Curcrete is applied to the exposed surfaces of concrete immediately after finishing and while the concrete is still soft and wet. Application is in the form of a fine spray which covers the surface with a thin film of contrasting color, easy to see and thus determine the sufficiency and thoroughness of the application. No further attention is required by either the contractor or inspector after Curcrete is applied, except to barricade the road to traffic in the usual manner and for the usual length of time.

In order to provide sure means of properly applying this material, this company has developed and offers for sale its Iroquois Curcrete spraying machine for this purpose. This apparatus, in principle, consists of a pressure tank to hold the Curcrete, an air compressor operated by a gasoline motor, and spraying nozzle, valves, etc., all mounted upon a frame as a single unit for convenient movement.

This spraying device operates under pressure up to 90 lb. and while sturdy and dependable has been designed to operate at a minimum cost for power and with as little labor as possible. It is estimated that one man with this apparatus can easily cure concrete as fast as it can be laid by the most approved machinery, if assisted at intervals in filling and moving the machine.

The method of curing concrete by the application of Curcrete or any other adherent film impervious to water while the concrete is soft and wet is protected by U. S. Patent No. 1,684,671, as well as by many foreign patents, which are owned by this company.

Like all Iroquois Hotstuf heaters, the Iroquois combination tool and asphalt heater, trailer type, has the elevated melting chamber which provides a concentrated, even distribution of heat, provided by an improved Iroquois torch type oil burner.